PRACTICAL

JUNE 1988 · £1.25

ELECTRONICS

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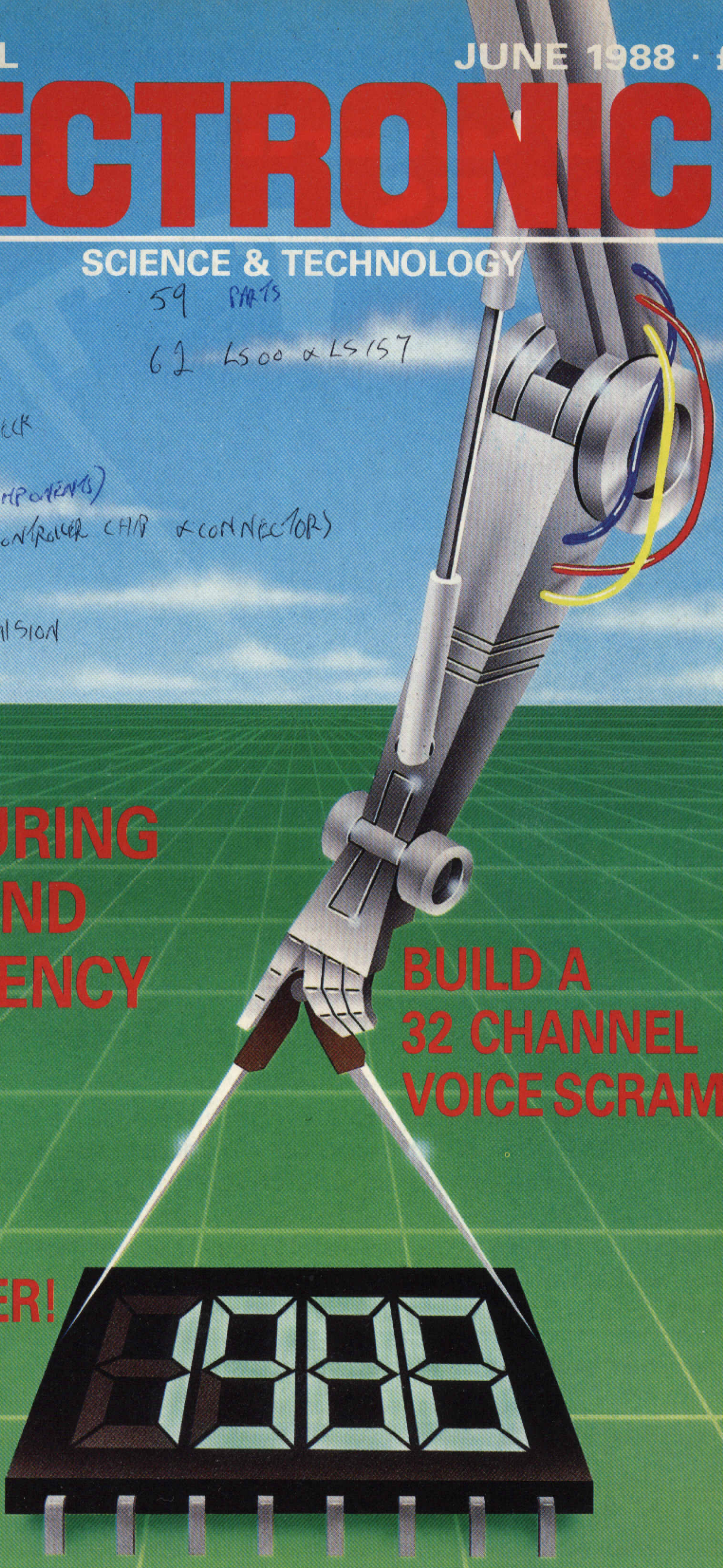

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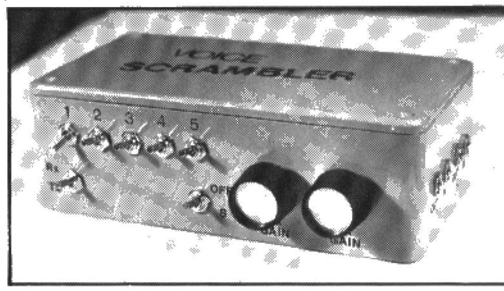
THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

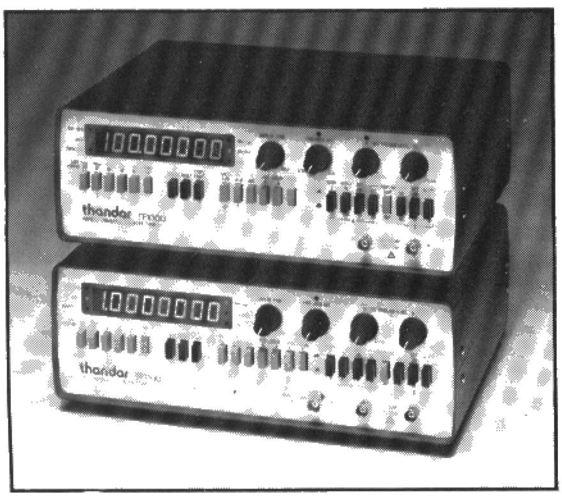
PRACTICAL ELECTRONICS

PE VOL 24 NO 6 JUNE 1988

COMPETITION



CONSTRUCTIONAL PROJECTS



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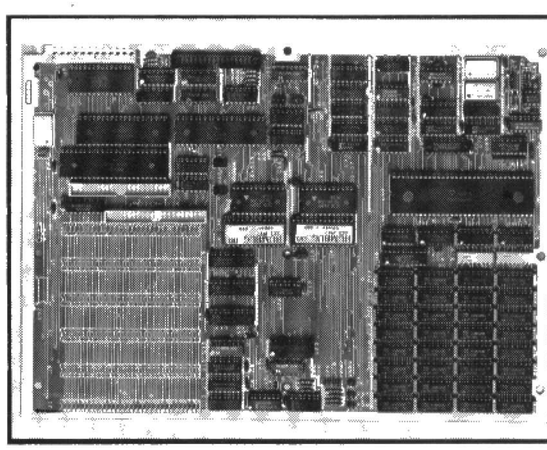
REGULAR FEATURES



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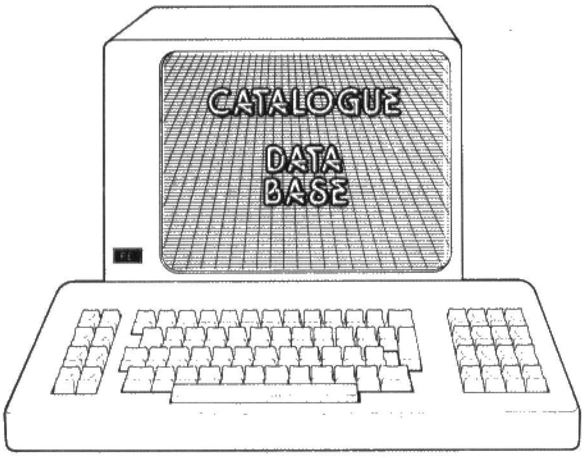
THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS



We have recently received the following catalogues and literature:

Pops Electronics wholesale catalogue of electronic hardware is available **free to anyone in the trade** looking for a good supplier. **Pops Electronic Components Ltd,** Studio D, unit 9A, Atlas Village, Oxgate Lane, London NW2 7HU. 01-450 4688/9.

Megger Instruments shortform catalogue shows their **full range of test equipment** ranging from continuity testers to temperature probes. **Megger Instruments Ltd,** Archcliffe Road, Dover, Kent, CT17 9EN. 0304 202620.

Computionics have sent their brochure on **Nursecall 800 equipment** that is specially designed to answer the need for an economic and reliable call system for use in hospitals, and nursing homes etc. They have also sent their **security and fire equipment** catalogue and price list. **Computionics Ltd,** Stephen's Way, Goose Green, Wigan, Lancs, WN3 6PH. 0942 322744.

PE ADVERTISERS — some of you seem to be overlooking this shop window — why not **send a copy of your catalogue** for mention in this column?

**GOT A CATALOGUE?
THEN SOCKET TO THEM
WITH A PLUG IN PE**

More Red Tape?

During a recent session of the European Parliament the music industry witnessed a postponement in its campaign for Europe-wide private copying royalties on blank tapes and equipment.

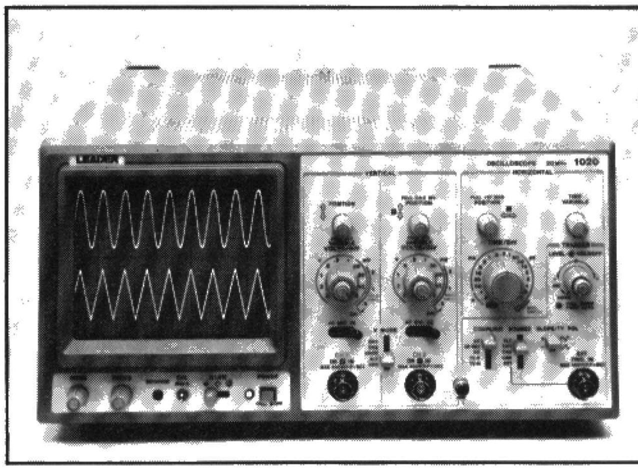
An impressive blueprint for the increased teaching, promotion and dissemination of music in the European Community was outlined. The report proposed that the Community's priorities should include tax incentives for cultural initiatives and included a controversial clause calling for private copying royalties to be levied on blank tapes and hardware for the benefit of copyright owners. The clause was supported by several political parties though some individual delegates expressed objections which contained considerable ground for optimism for the music industry.

The Commission will intensify its efforts to combat audiovisual piracy in defence of the interests of the recording industry in Member States. Referring to what was described as the "highly explosive problem of private copying", the Commissioner said he recognised the arguments, put forward by MEPs on behalf of the consumers, but stressed that there are also other equally valid arguments regarding the interests of the authors and of the EC phonographic industry which have to be thoroughly taken into account.

In the light of the blueprint outline, and in anticipation of the Commission's forthcoming Green Paper, the clause on private copying was not adopted, and it was suggested that further discussion should be postponed until the Parliament could benefit from the information and proposals shortly to be published by the Commission.

Contact: IFPI Secretariat, 54 Regent Street, London W1R 5PJ.

WHAT'S NEW



Low Cost Dual Scope

Thandar Electronics are pleased to announce the introduction of a 20MHz dual trace general purpose oscilloscope under the Leader brand name, designated the LBO-1020.

It is a 5mV/div, 20MHz (500 ΩV/div, 4MHz) portable dual trace oscilloscope with a maximum sweep speed of 50 ns/div (mag × 10) and 150mm crt with internal graticule.

The major features include an illuminated graticule, a special trigger pick off circuit which ensures synchonisation with composite video signals. Alternate trigger mode allows the stable display of two asynchronous signals plus display modes for CH-1, CH-2, CHOP, ALT, ADD and Polarity CH-2 INVERT plus X-Y operations.

The LBO-1020 is supplied complete with probes at a price of £315.00 + VAT.

Contact: Thandar Electronics Ltd., London Road, St. Ives, Huntingdon, Cambs PE17 4HJ. Tel: 0480 64646

Weather Imaging

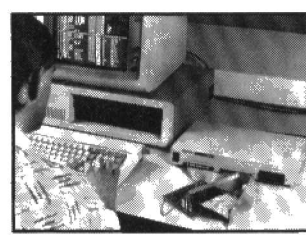
Mitsubishi of Japan has recently developed a weather image information displaying system for All Nippon Airways (ANA).

The system automatically collects image information on weather conditions from a weather satellite, weather radars and weather maps, and displays any of these on terminal screens installed 30 airports served regularly throughout the country by ANA. It provides accurate weather information to pilots promptly, ensuring safe and comfortable flights for passengers.

It consists of a main control system in Tokyo, a collection/delivery system in Osaka and in Fukuoka, and 38 terminal systems installed at the 30 airports.

Delivery of information is done automatically via telephone circuits to save labour while transmission during the night can also slash cost. The use of phone lines facilitates future addition of terminals either in Japan or abroad.

The terminal is equipped with a mouse to enable the operator to use the machine easily, without any special training, by following instructions on the screen.



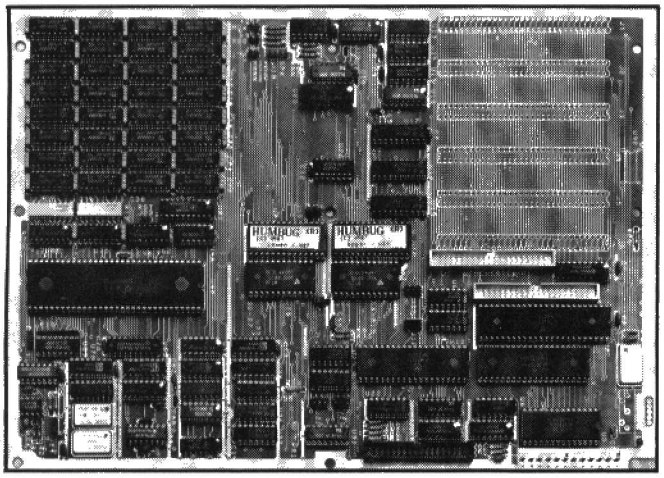
Orion Rises

A microprocessor development system that not only speeds up debugging, but lets you watch the enhanced process, has been launched by Megger Instruments.

The Orion 8620 is one of a series of major no-compromise computer integrated instrumentation announcements expected over the next few months from Megger. The new system has a high speed parallel interface; advanced bus analyser and 2730 bus cycle trace buffer, which together make possible its unique InSight feature.

InSight allows the user to watch the debugging program in real time as it blends analyser and emulator techniques. The continuous monitoring capability covers I/O lines, ports and user defined memory windows. The fast interface also speeds data throughput.

Contact: Megger Instruments Limited, Archcliffe Road, Dover, Kent. Tel: 0304 202620



Computer Kit

Micro concepts have introduced a single board computer which is available in kit form.

The PT68K-2 designed around the powerful Motorola MC68000 microprocessor and the board provides exceptional performance at very modest cost with the user adding only those additional facilities required.

A unique feature of the PT8K-2 is in the implementation of an IBM PC/XT compatible i/o bus for low cost system expansion.

On board memory consists of 1024K of no wait state dynamic ram which can be populated 512K at a time using low cost devices. A floppy disc controller supports up to four drives which may be either 5.25 or 3.5 inch types. The PT68K-2 also supports two types of Winchester hard-disk controller.

Four serial RS232 ports are provided each of which has software programmable baud rates and data format. Two 8 bit parallel input/output ports with interlocked handshake lines are available for control purposes or may be used to drive Centronics type printers.

A battery backed real-time clock, programmable sound source and 4K of static ram completes the list of on board facilities.

A basic kit of components, which build into a minimum configuration 6800 computer board is priced as £295 plus VAT. Included are a high quality silk screened pcb measuring 12 by 8.5 inches, 8Mhz cpu, two RS232 serial ports, 4K static ram, debug monitor and all support components. Documentation for expanding to a full sytem is supplied including full circuit diagrams and parts lists.

Contact: Micro Concepts, 2 Stephens Road, Cheltenham, Glos. GL51 5AA. Tel: 0242-510525

COUNTDOWN

If you are organising any event to do with electronics, big or small, drop us a line – we shall be glad to include it here.
NOTE: Some events listed here may be trade or restricted category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

May 12-14. Compfest 88 – National Computer Festival. Telford Exhibition Centre. 0952 505522.

May 18-19. Laboratory Manchester. New Century hall, Manchester. 0799 26699.

May 18-20. ShowTech 88 Berlin. International trade fair and congress – entertainment technology. Berlin exhibition ground.

May 22. Swindon & District Amateur Radio Club annual rally and hobbies fair, including display support by the British Science Museum, helicopter trips, and a steam engine rally. It looks like an excellent day's outing at Wroughton Airfield, Nr Swindon, Wilts. 0666 89307.

May 24-26. Computer North. G-Mex Exhibition Centre. Manchester.

Jun 8-9. Infrared Technology. Wembley Conference Centre. 0799 26699.

Jun 26. Radio Society of Great Britain mobile rally. Longleat. (No CBs!). 0272 848140.

Sep 6-8. Coil Winding. Wembley Conference Centre. 0799 26699.

Sep 8-12. Sim-Hifi-Ives. International video and consumer electronics show. Milan. 02-4815541.

Sep 14-18. PCW Show, Earls Court. 01-636 3205.

Sep 27-30. DES. Design Engineering Show. National Exhibition Centre. Birmingham.

Oct 18-20. Internepcon. Electronic Packaging Show. Metropole Convention Centre, Brighton.

Nov 1-3. Custom Electronics & Design Techniques Show. Heathrow Penta. 0799 26699.

Nov 29-Dec 1. DMC-PC. Drives, motors, programmable controllers etc. National Exhibition Centre, Birmingham. 0799 26699.

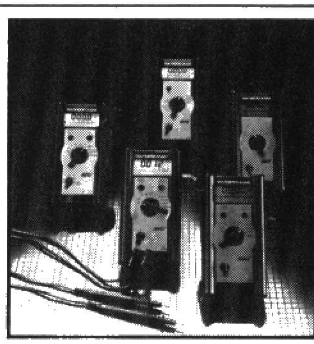
Pineapple Update

Pineapple has recently updated its popular PCB printed circuit drafting program and, as well as many improvements in the standard rom, there is now a second rom available which gives the program full automatic track routing capabilities.

The autorouting option is available to work with its full features even on a standard unexpanded BBC micro, and the success rate of the autorouting is very high, equivalent to, if not better than, similar programs running on IBMs at many times the price, say Pineapple.

The autorouting update is available to registered PCB owners at £55.00.

Contact: Pineapple Software, 39, Brownlea Gardens, Seven Kings, Ilford, Essex IG3 9NL. Tel: 01-599 1476.



Advancing AVO

The world's first range of high-resolution dynamic pointer analogue/digital multimeters, the AVO M2000 Series, is available from STC Instrument Services.

Until now instruments featuring both digital and analogue readings have offered only a limited analogue capability which has normally been in bar form. This series offers a dynamic response analogue display with high resolution which provides an accurate measurement of a particular value plus a clear indication of its variations.

Comprising five hand-held instruments, the series features autorange, range hold, data hold and peak hold facilities; analogue lcd scales with 70 divisions; integral probe holders; good freqency response; and true rms measurement.

Encased in a highly rugged rubber buffer, these instruments offer accuracy extending from ±0.7% for the M2004 to ±0.1% for the M2007 and M2008 with an operational voltage range from 300mV to 1000V.

Contact: STC Instrument Services, Dewar House, Central Road, Harlow, Essex CM20 2TA. Tel: 0279 641641

Citizens Banned?

No, it's not citizens who are to be banned from the RSGB's Longleat mobile rally in June, it's their cb radios!

The Radio Society of Great Britain are holding their rally on Sunday 26th June 1988 and extend a warm welcome for anyone and everyone to attend. If past years are anything to go by, it should be a good day's outing. The rally starts at 10.00 a.m. Longleat Park is near Warminster in Wiltshire.

Further information is available from Brian Goddard, the Chairman of the Bristol RSGB, 2 Greenfield Park, Portishead, Bristol, BS20 88NQ. Tel: 0272 848140.

Speedy Stripper

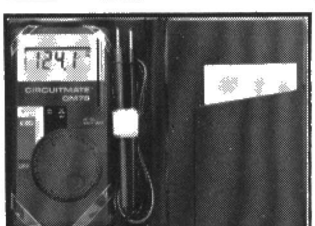
An indispensable item for any tool box whether it be that of the electronics engineer or the DIY enthusiast is a gadget that makes wire stripping fast and simple.

Ceka's new adjustable precision wire stripper, type number 3756, is a professional quality tool that can cater for diameters of 0.25mm to 0.8mm which are selected by simply turning a clearly marked adjustment wheel.

Lightweight in construction, the stripper has specially hardened blades to ensure long life and efficient stripping of both PVC and Teflon coated wires.

Fast to operate, simply set the adjustment wheel to the wire size, pass the wire through the holes, squeeze the handles and withdraw it. An adjustable length marked in 5mm graduations ensures accuracy. it costs just £25.50.

Contact: Ceka Works Limited, Pwllheli, Gwynedd, North Wales. LL53 5LH. Tel: 0758 612254



Mini Measure

A miniature autoranging digital multimeter, small enough to slip into a shirt pocket, has been introduced by Beckman Industrial at a price of only £24.50 plus VAT.

Designated the DM78, the 3.5 digit meter has five functions which can measure up to 250 volts ac in four ranges, 250 volts dc in five ranges, 20Megohm in six ranges, and check diodes and continuity with an audible beeper.

The autorange feature automatically sets the optimum measuring range to simplify operation and avoid overloads. Measured values are easy to read on the ⅜in high display.

Measuring only 4.25 × 2.13 × 0.40in, the meter is supplied in a neat wallet together with the test leads.

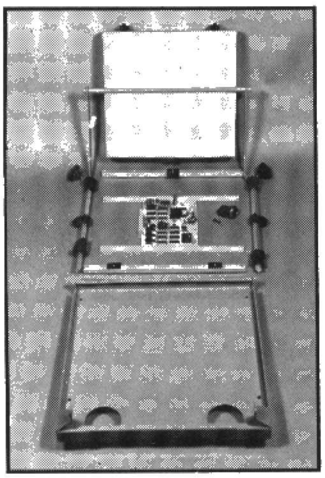
Contact: Beckman Industrial Ltd, Temple House, 43-48 New Street, Birmingham B2 4LJ. Tel: 021-643 8899

PCB Frame-up

Wybar Electronics have announced the availability off a complete spare parts facility for their WY series printed circuit board assembly holders.

Spare parts as diverse as complete lid assemblies with anti-static or conductive foam to springs and ball bearings from the moving rails are stocked, as well as a range of five sizes of complete units to suit most printed circuit boards.

Contact: Wybar Electronics, Unit M, Portway Industrial Estate, Andover SP10 3LU. Tel: 0264 51347/8.



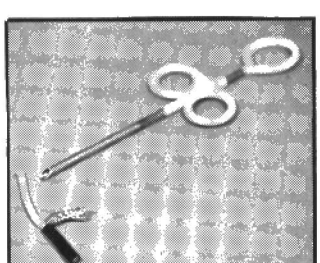
Strip Coax

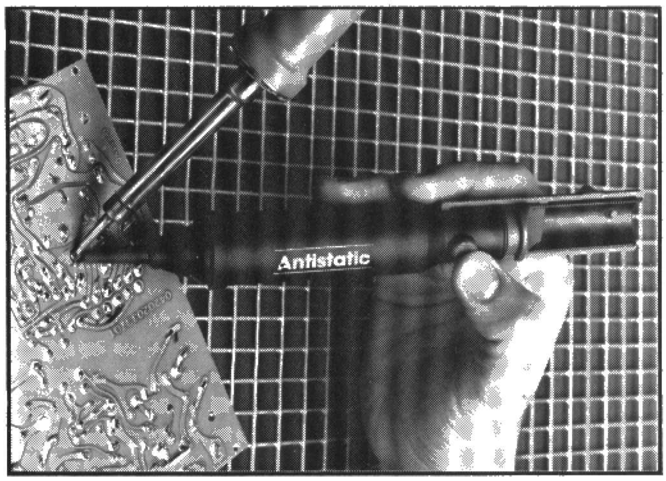
Rush Wire Strippers have introduced a new range of lead extractors which eject the lead wire of shielded and coaxial cable through the braided shield.

The action of the tool is similar to a hypodermic needle — the sharp tip of the blade penetrates the braided shield and the plunger ejects the lead wire through the braid wall. This eliminates intensive unpicking and pigtailing of the braid which is left intact for neat soldering or other operations.

The extractors are available for inner lead wires up to 3.3 mm diameter.

Contact: Rush Wire Strippers, Unit M, Hunting Gate, Andover, Hants. SP10 3LU. Tel: 0264 51347





Suck it and see

A must for everyone involved in the precise application of solder is a tool for the efficient removal of it. Added to Ceka's range of specialist tools electronics is a new antistatic desoldering pump which features a variable spring action suction pump.

The suction power is varied by simply unthreading the nozzle of the pump and turning the spring to either the 'soft' or 'strong' suction position, which provides a strong, but muffled and recoilless suction.

The desoldering pump, which is made from black antistatic nylon glass plastic, clears solder through a heat resisting and non-stick carbon fibre tip upon reloading.

Manufactured to a professional pattern and quality, Ceka's desoldering pump type 6103 is supplied in individual wallets with full instructions for use and maintenance and costs a very reasonable £11.00.

Contact: Ceka Works Limited, Pwllheli, Gwynedd, North Wales LL53 5LH. Tel: 0758 612254.

CHIP COUNT

MVA1000. Video amplifier giving excellent performance over video bandwidth of 0–10MHz, but also offering very functional performance up to 30MHz. **(MC)**.

RQT100G. Toko pico delay line chips. Two versions — 2ns and 5ns respectively with 10 taps. Delay per tap is 200ps and 500ps. **(CK)**.

SCB68155. 68000 systems interupt handler reducing component count and simplifying circuit design. **(ML)**.

TP1465. Extremely fast fet input, vmos output opamp operating from ±15V to ±40V at currents up to 750mA. **(MC)**.

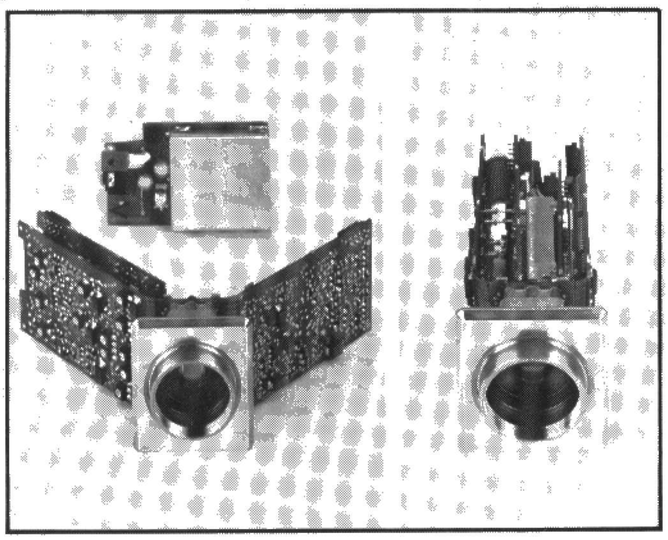
TSA6057. Phase locked loop frequency synthesiser providing ultra-stable reference for digital car radios. **(ML)**.

Manufacturers, and contact telephone numbers:

(CK) Cirkit Distribution, Park Lane, Broxbourne, Herts, EN10 7NQ. 0992 464457.

(MC) MCP Electronics, 26–32 Rosemont Road, Alperton, Wembley, Middx. HA0 4QY. 01 902 6146.

(ML) Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. 01 580 6633.



Easy CCD Imaging

Mullard have announced a sub-assembly based on their ccd image sensors and requiring only a chassis and lens to form a complete black-and-white video camera for use in machine vision, surveillance and similar applications. This is the first video camera sub-assembly incorporating a Philips solid-state image sensor on the market.

The unit consists of a solid-state image sensor (ssis), and all the necessary drive, pre-processing, and power-supply circuits. There are two basic versions for 525-line or 625-line TV systems meeting EIA or CCIR standards; these are both avail-able in three different sensor quality grades. By simply adding a lens housing, cabling and connecting the unit to a computer or monitors, a user has the basic hardware for machine vision system.

The sensor used in the unit has an image area of 6.0 by 5.4 mm. It works down to an ambient light level of 1 lux, the light condition at twilight. All electronic circuitry is supplied on a flex-rigid printed-circuit board which may be folded depending upon the appliction. Advanced surface mounting techniques allow the size of the sub-assembly to be just 89 by 40 by 45 mm with the pcb folded.

Contact: Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. Tel: 01-580 6633

RCB Adaptor Plug

STC Electronic Services has introduced the new MK Safeguard RCB adaptor plug to complement its MK Sentrysocket range.

Designed to provide immediate mobile earth fault protection by simple insertion into a standard 13A socket, the adaptor features sleeved pins, double pole isolation and a patented safety shutter on live and neutral.

As an added safety facility, the SafeGuard will trip-off if it is removed from the socket or if the power supply is cut. More importantly, it will not automatically restore power to dangerous tools etc following an interruption until the reset button is manually operated.

The adaptor operates with a 30mA trip current, is fitted with a test button to ensure satisfactory function and features a mechanical indicator for maximum safety. If necessary, two units may be fitted into a twin 13A socket outlet.

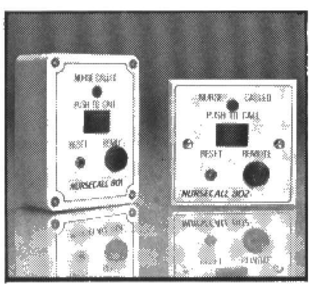
Contact: The Tool Group, STC Electronic Services, Edinburgh Way, Harlow, Essex CM20 2DF. Tel: 0279 626777

Eureka HDTV

The Department of Trade and Industry, have announced that they will be providing £2.5 million financial support for BBC and participation in a major Eureka collaborative project to develop a high definition television (hdtv) system.

The UK broadcasters will be playing an important role in the first major demonstration of the Eureka hdtv transmission and reception system, planned to take place in September 1988. Further demonstrations will take place in 1989, with the objective of having the Eureka system adopted as a world standard by the CCIR (the international radio standards body) in 1990.

The aim of the Eureka hdtv project, which involves some 30 European industrial companies, broadcasters and research institutes, is to define a standard for hdtv which is compatible with the mac (multiplexed analogue components) transmission system being introduced for direct broadcasting by satellite (dbs) services in Europe.



Nursecall

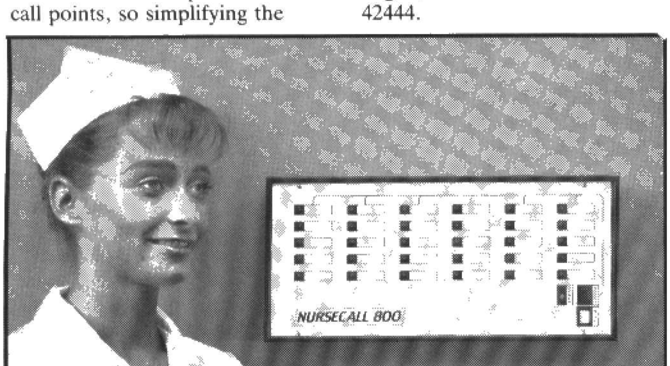
A unique patient-nurse call system is available from Computionics. Nursecall 800 has been designed to answer the need for an economically priced and reliable call system with the flexibility to answer the needs of different residential properties.

Computionics approach has been to design the call system with the electronics placed in the call points, so simplifying the control panels and the interconnecting wiring.

To call for help the patient pushes a button or pulls a cord. A light comes on to show the call has got through, and if required, a light can come on over the patient's door, and audible warning devices sounded. At one or more control panels a beeper calls for attention and an indicator lights to say which room is calling. When the attendant goes to to the room a small reset key is used to cancel the call.

Other versions are available with extended facilities, and Computionics also have a new fire alarm control panel available at a competitive price.

Contact: Computionics, Stephen's Way, Goose Green, Wigan, WN3 6PH. Tel: 0942 42444.



Red Alert Home Security

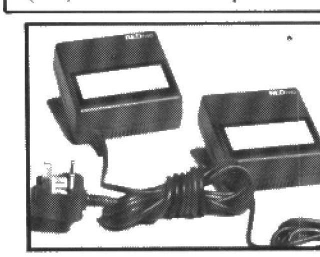
A new six page full colour brochure is now available from General Information Systems explaining the benefits and applications of their Red Alert home security and alarm system. It also provides information on the increase in domestic burglary and why it is neccessary for home owners to protect their properties.

Red Alert does not require any additional wiring since it utilises the existing domestic circuitry. The modules, or Red Boxes, plug into 13 amp sockets and communicate with each other via the ring main. At around £150, the starter pack contains the control unit, Red Alert, which has a 105 decimbel alarm and a key to 'arm' and 'disarm' the system plus two RedTwo devices. These are wide angle infra-red sensors which can detect an intruder up to 16 feet away.

Once armed, if a Red Two senses movement, the alarm will sound within 40 seconds. The system can only be deactivated with a key and, should the power supply be cut, Red Alert's battery will take over and the alarm sound within two seconds.

(Your Ed wonders: What happens in the event of a normal power failure?)

Red Alert was nominated for a 1987 award under the Electrical



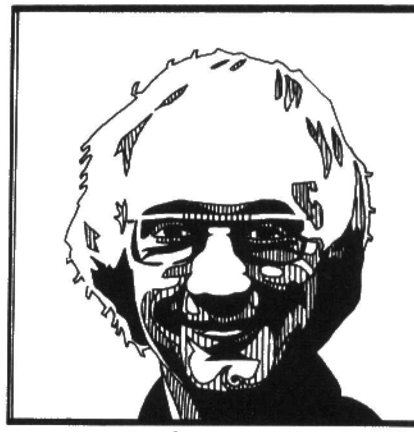
Products magazine annual scheme for outstanding electrical products. It also complies with the new BSI (Band C) regulation for mains bearing products for home automation.

Full details and technical specification are included in the brochure which is available free by writing to CFPR Ltd., 148 Temple Chambers, Temple Avenue, London EC4Y0DT. Tel: 01-583 2444.

ZAPPING STUN GUNS

By Barry Fox
– Winner of the 1987 UK Technology Press Award

Electronic stun-guns have been banned in the UK – after they proved popular with muggers. More good news: your compact discs won't be going 'laser-proof' despite the experiences of video-disc owners.



Shops and mail order firms have been openly selling electric stun guns. They boast in their adverts that these guns — costing around £50 — can "temporarily freeze the nervous system" and "stun and immobilise for up to 15 minutes".

Although stun guns are advertised as offering personal protection against muggers, inevitably criminals have started using them. A youth in Biggin Hill, Kent, was robbed by muggers armed with stun guns. They used it on his head and body. The charge went through his clothing.

Until recently retailers could get away with selling what is clearly an offensive weapon because of a loophole in the Firearms Act. Section 5 of the 1968 Firearms Act lists prohibited weapons, such as noxious gases and liquids, but does not specify electric shock weapons. The police can charge someone for selling or carrying a stun gun, but the lack of any specific mention in the Act leaves the carrier free to argue that the gun was not being offered or carried as an offensive weapon.

The crunch came when a shop prosecuted for selling stun guns, appealed against conviction and won. So selling and possessing stun guns was no longer automatically a criminal offence. Then the police went to the House of Lords, and won a final appeal. So selling and possessing stun guns is now prohibited again. Nevertheless the police, and Home Office, want all holes plugged. They have seen what's happening in America.

In the US, stun guns are readily available. Recently published patents tell how different types work. One looks like a tv remote control. It contains a 9 volt battery, with oscillator and step-up transformer which produces 20 pulses a second at 50 000 volts. These pulses are fed to two metal studs at the front end. When an "on" switch is pressed and the studs pushed against someone's skin, for instance their neck or hand, the high voltage pulse train stuns them into submission.

Another type works on the same principle as gadgets already sold to light the gas or create a stream of ions which discharge static electricity from gramophone records. This stun gun looks more like a pistol, with a blunt electrode point at the barrel end. Inside the pistol there is a piezoelectric crystal and series of capacitors. When a trigger is pressed, a hydraulic gear mechanism compresses the crystal to generate a surge of electricity which is stored in the capacitors. The harder and more often the trigger is squeezed, the stronger the stored charge. When the pistol is pushed onto the subject's skin, the electrode discharges the capacitors in a jolting shock.

The nastiest type, used by the police in America, shoots barbed arrow electrodes at the victim. These are connected by wires to the voltage source. This allows the user to immobilise someone without getting close to them.

Flushed with success in the Lords, the police recently raided a shop in North London and confiscated 25 stun guns. As a result it is likely that reputable magazines and newspapers will now stop taking mail order adverts.

To be on the safe side, the Home Office has been trying to change the Firearms Amendment Bill, while at committee stage in the House of Commons. Section 5 would in future specify that electric shock weapons are "offensive". This amendment would make it illegal to advertise and sell stun guns as well as carry them.

It would need the personal authority of the Home Secretary to own a stun gun. Not even the police can give permission. Anyone without a licence will be liable to a five year jail sentence and unlimited fine for possessing an offensive weapon. "And no individual holds any such licence", says the Home Office darkly — which for anyone who has suffered a 50,000 volt belt will come as welcome news.

When researching this story I spoke with a doctor who works as a police surgeon. "I am horrified," she said, "they could kill someone with a heart condition." I then asked the British Medical Association what they thought.

"We do not yet have a policy on stun guns," said the BMA, "but then there are lots of things on which we do not have a policy."

Some months ago, before the current publicity, PE was offered a stun gun as a constructional project. We rejected it outright. Ed.

LASER ROT

The videodisc industry blushes, and looks the other way, when asked about "laser rot". A few years ago there were substantiated reports of videodiscs becoming unplayable after a few months use. This was caused by air getting through to the aluminium layer which reflects the laser light. Once air gets to aluminium, it oxidises (rusts) and stops reflecting, so the disc can no longer play.

Happily the laser rot problem seems to have been solved. Disc manufacturers have tightened up on their production processes. They found that the glues used to secure the two halves of double-side videodisc together were the main culprits. Research has shown which glues to use and which to avoid.

Compact disc audio records are single-sided and need no glues. There have been no reports of "rotting" discs. But critics of cd still cast doubt on their long term life. As many people know from experience, clear plastic material can get cloudy and brittle when exposed to light, especially sunlight. The Philips DuPont optical joint venture, and Polygram, press more cds than anyone else in the world. They were recently quizzed on disc life. The answer was very reassuring.

Cds are pressed from a clear plastic called polycarbonate. The way to make it opaque would be to alter the chemical structure and make it "crystalline". Not possible under normal conditions, says PDO. You have to heat it to a temperature of above 190 degrees Celcius, which is far above its melting point. By that time the disc is useless anyway. PDO says that firms supplying raw polycarbonate have over 20 years of experience to confirm this.

During the 15 years PDO and Polygram have being pressing laser discs, first video then audio, they have run severe tests on videodiscs and compact discs using temperatures of up to 85 degrees Centigrade, air humidities of up to 100% and ultra violet radiation.

And they found no problems. Says PDO: the risk of crystallisation, and the disc becoming opaque, "can be excluded completely". PE

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EDUCATIONAL COOPERATION

A Government White Paper recently published acknowledges that the competitiveness of industry depends especially on the ability to harness energy, intelligence and enterprise amongst the young. The DTI, who published the document, are intent on bridging the historical divide between business and education by encouraging young people to work in industry and commerce, to bring greater relevance to their education and to prepare them better for working life.

The DTI states that it will work to further encourage employers to develop good links with schools, in particular by introducing employers to those who can help them become actively involved in education. Already there are many instances of schools and employers working successfully together supported and financed by Government and existing agencies. A pilot network of City Technology Colleges, sponsored by business and the Department of Education and Science is to directly involve employers in the management of secondary education to create a new kind of partnership. Curriculum reform, new exams and the Technical and Vocational Education Initiative are also helping young people to relate classroom learning to the world of work.

Taking this process further the Government will, in cooperation with employers, work towards achieving three main objectives — that every year ten per cent of teachers should have the opportunity to gain personal experience of the business world; that every young person should have at least two weeks work experience, suited to their abilities and needs, before leaving school; that every trainee teacher should gain an appreciation of employers' needs and of the importance of the links between schools and employers.

The DTI also wish to ensure that information technology is used across the curriculum in conjunction with education databases. Five million pounds have been made available to support computer aided design, interactive video, and other forms of advanced technology in schools, further education colleges, and teacher training establishments.

It is encouraging to read that the further education sector has shown a growing response to the changing needs of industry and commerce, particularly in relation to the work related education programme of the Manpower Services Commission. Further good news is that, following the success of the previous Industry Year Award for collaboration between industry and education, a further award will be launched this year and that a guide to maximising the benefits of collaboration is being prepared by the DTI.

PE would have welcomed additional information about the DTI's intention towards enabling schools to acquire more science and technology equipment, but at least the report appears to recognise the necessity for ensuring that Britain remains a technologically educated nation.

THE EDITOR

32-CHANNEL VOICE SCRAMBLER

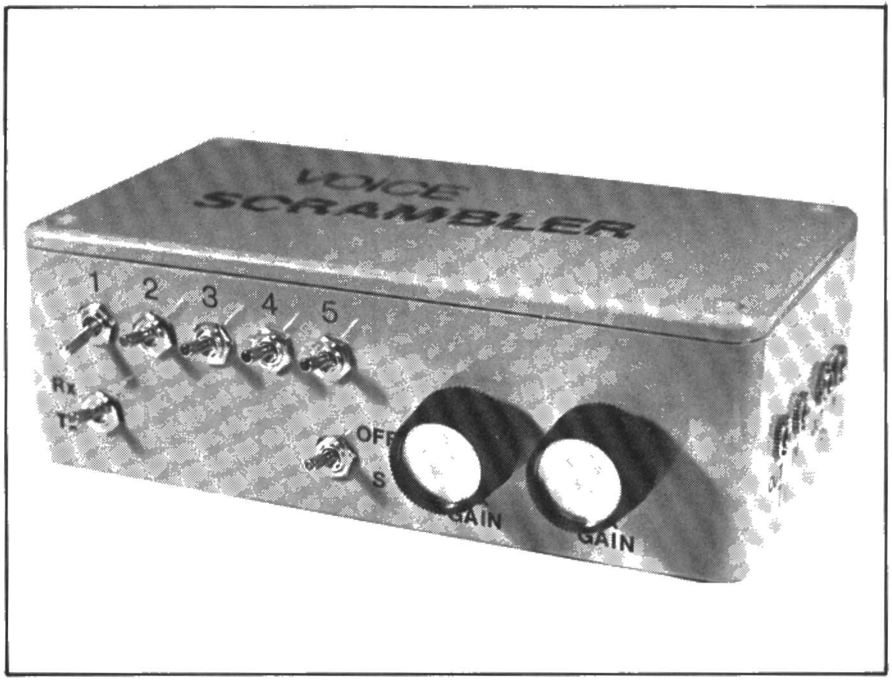
BY MALCOLM HARVEY

A NEW UPSIDE-DOWN LOOK AT SPEECH SECURITY

The new FX224 signal scrambler chip forms the basis for this frequency inverting scrambler module. Not all the chips functions are used, but details are given so that the module can be adapted to the users' application.

Technology marches on and one of the many areas that benefits from increased sophistication is security. Several security articles have recently been published in PE, notably the burglar alarm system by Bill Kent in Nov and Dec 87, the electronic locks articles by the Prof in Jan and Feb 88, and going back to Jan 87, Robert Penfold described a circuit that would give security to voice transmissions by scrambling them.

That circuit represented a sophisticated approach to voice scrambling in the light of the technology available at that time. The basic principles of the technology are still valid and I commend RAP's article to anyone interested in frequency inversion theory. In the intervening months since the article was published, technology has moved on sufficiently to justify taking another look at voice security by describing a new scrambling chip that has been recently introduced.



CHIP FAMILY

The chip is one of a family of devices produced by Consumer Microcircuits. There are basically three chips in the family, consisting of the FX214, FX224 and FX234, though the project to be described will only be concerned with the FX224 in the dil package.

The principle points of interest in these chips are that they use frequency inversion techniques to scramble the signals, and that they have 32 different carrier frequency options, giving a choice of 32 different scrambling paths, so offering enhanced transmission security.

Other points of interest are that their features include continuous tone controlled squelch system (ctcss) hp filtering, high recovered audio quality, half-duplex switching and a powersave facil-ity. They can be used in fixed or rolling code applications, have serial or parallel load options, and are available in dil and surface mounting (smd) packages.

The type numbers relate as follows—
- FX 214J 22-pin dil serial load
- FX214LG 24-pin smd serial load
- FX224J 24-pin dil parallel load
- FX224LG 24-pin smd parallel load
- FX234LH 28-pin smd serial and parallel load

BLOCK FUNCTIONS

The functional block diagram for the family is shown in Fig.1.

The chips are low power cmos lsi devices that use separate rx (receive) and tx (transmit) paths which are switched for half-duplex operation (ie, you use a switch to alternate between transmit and receive). To prevent interference from sub-audio harmonic products the chips include a continuous tone controlled squelch system (ctcss) high pass filter that is automatically switched to the selected rx or tx path.

INVERSION

Speech signals are scrambled by splitting their frequencies into upper and lower bands by means of switched capacitor filters. Each band is then modulated by a switch-selected carrier frequency which effectively inverts the band frequency. In this way, high frequencies become low frequencies, and low frequencies become high. The two inverted frequency paths are summed at the output and become the 'scrambled' signal. If you listen directly to this signal, it is totally incomprehensible, and can only be understood by using a second scrambler as a decoder.

There are 32 different split-point and carrier frequency combinations, and they are externally programmable using a 5-bit switching code. For the project to be described the switching is done manually by panel mounted switches.

ROLLING CODES

Since the chips are ttl compatible, the switching could of course be achieved by coupling the 5-bit input pins to a computer. In that instance, the computer could step through the 32 switching combinations in a pre-arranged sequence to further minimise the chance of someone with a similar unit being able to unauthorisedly intercept and decode the transmitted speech. Such operation is known as 'rolling code' operation. It would of course necessitate some sort of

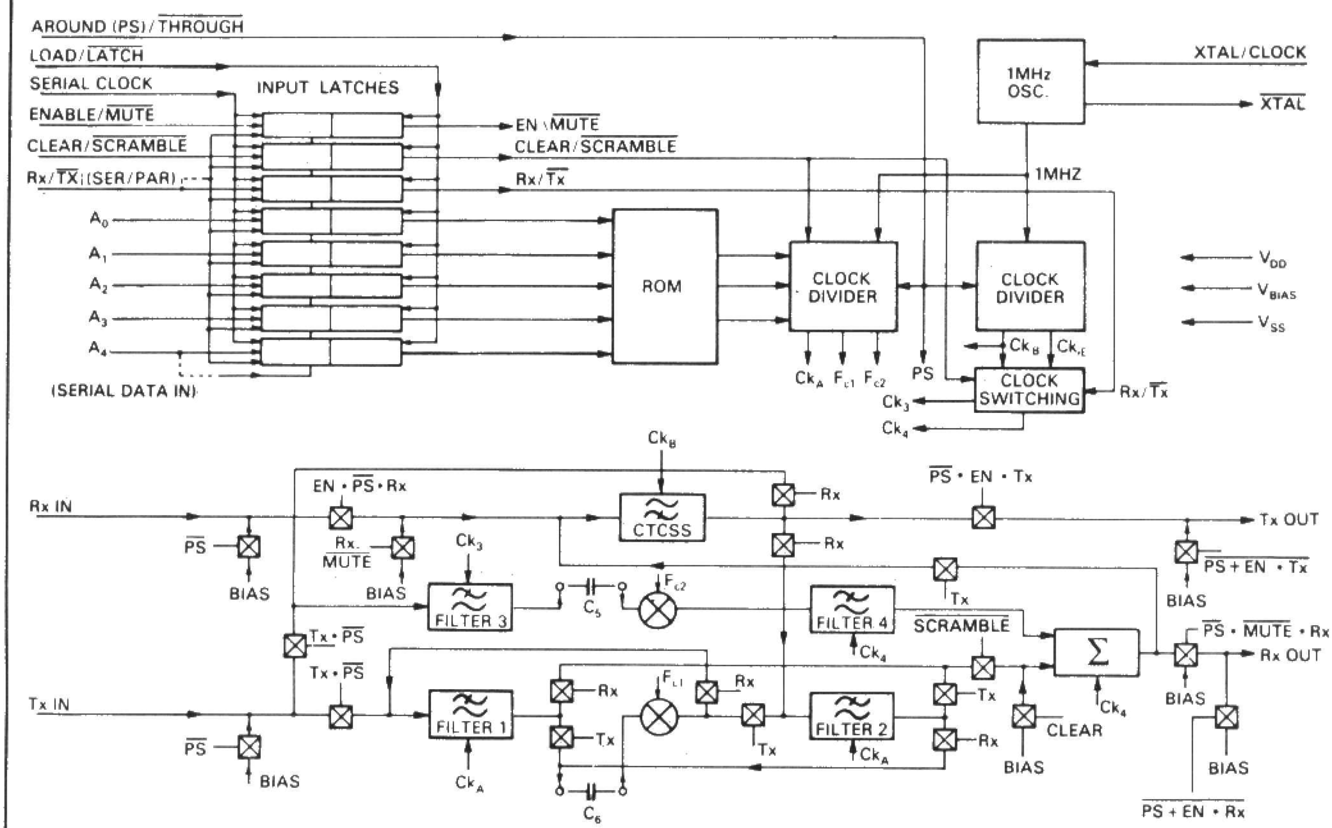


Fig. 1. *Functional block diagram.*

synchronisation signal to also be transmitted so that the receiving circuit can be kept in step with the program controlled switching sequence.

Of the other switch selectable options on the chips, namely sync-speech mute, powersave, clear and audio bypass, only the latter will be used, though sufficient information will be given to allow anyone interested to experiment with the extra facilities. Each logic function pin has an internally connected 1M pullup resistor.

QUALITY CONTROL

The accuracy of the capacitor switched filtering and modulation signals requires the use of a stable clock generator. This can be applied from an external source, or by taking advantage of the 1MH on-chip oscillator used in conjunction with a 1MHz crystal.

The audio quality of the decoded speech signals is not up to hifi standards since the device is deliberately designed to only pass frequencies between 300Hz and 3.4kHz. Within this limitation, the recovered speech quality is very good, and is similar to that experienced when listening to an extremely clear telephone conversation.

The full pinout connections for the FX224 are shown in Fig.2.

PROGRAMMING INPUTS

A0 to A4 are the pins to which the coding switches or computer output lines are connected. The code is defined by whether a particular pin is held high or low, in normal logic fashion. Since there are five pins, any of 32 options are selectable by the relevant binary code from 00000 to 11111. The frequency parameters selected by these codes are shown in Table 1.

RECEIVE-TRANSMIT

Pin 8 selects whether the chip is to be used in rx or tx mode by taking it high or low respectively. It automatically configures bandwidths of the upper and lower band filters, and sets the ctcss high pass filter in the correct signal path. Figs.3 and 4 show the equivalent block diagrams for the selected paths, and Table 2 gives the equivalent functions.

CLEAR-SCRAMBLE

This pin when high puts the device in to the clear transmission mode in which no scrambling takes place. In the clear mode, the carriers are turned off, the balanced modulators are bypassed internally and the lower band signal is not added to the output signal. When the pin is held low the frequency

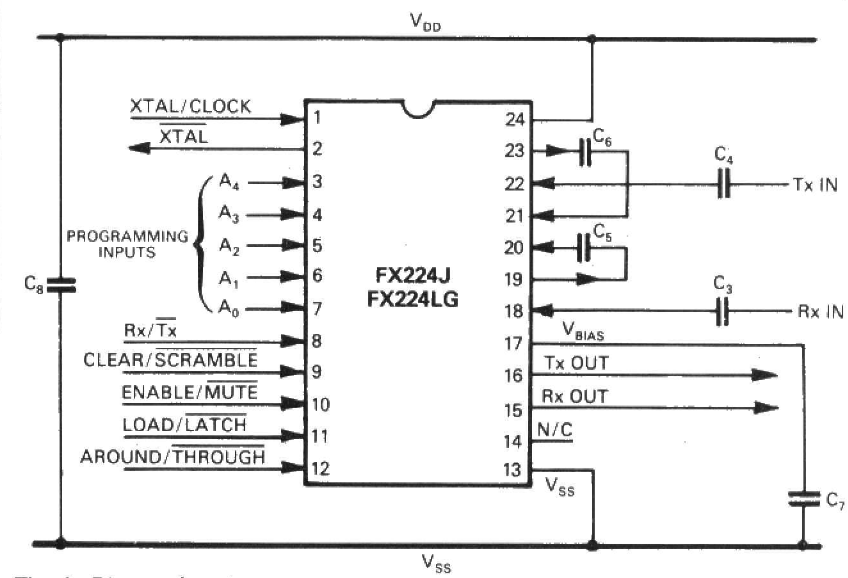


Fig. 2. *Pin-out functions.*

ROM Address A_4-A_0	Split Point Hz	Low Band Carrier, Hz f_{c1}	High Band Carrier, Hz f_{c2}
00000	2800	3105	6172
00001	2625	2923	6024
00010	2470	2777	5813
00011	2333	2631	5681
00100	2210	2512	5555
00101	2100	2403	5494
00110	2000	2304	5376
00111	1909	2212	5263
01000	1826	2127	5208
01001	1750	2049	5102
01010	1680	1984	5050
01011	1555	1858	4950
01100	1448	1748	4807
01101	1354	1655	4716
01110	1272	1572	4629
01111	1200	1501	4587
10000	1135	1436	4504
10001	1050	1351	4424
10010	976	1278	4347
10011	913	1213	4310
10100	857	1157	4273
10101	792	1094	4166
10110	736	1037	4132
10111	688	988	4065
11000	636	936	4032
11001	591	891	3968
11010	552	853	3937
11011	512	813	3906
11100	471	772	3846
11101	428	728	3816
11110	388	688	3787
11111	350	650	3731

Table 1. *ROM address programming table.*

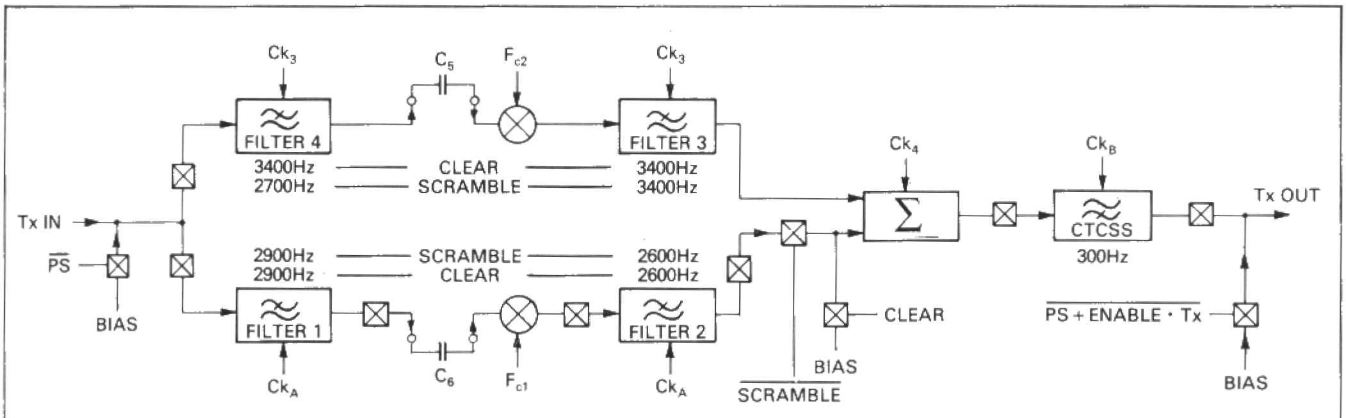


Fig. 3. *Basic transmit path*

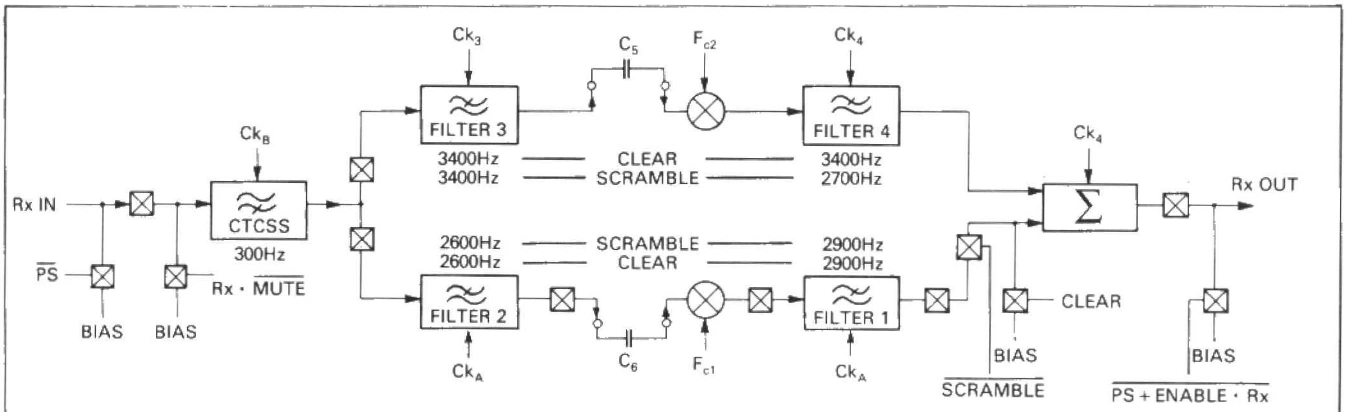


Fig. 4. *Basic receive path.*

Effect of Chosen Function on Inputs and Outputs		CHOSEN FUNCTION: Rx = '1'	$\overline{Tx}$ = '0'	$\overline{Mute}$ = '0'	Around (Powersave) = '1'
Rx Input	Path	Enabled	Disconnect	Disconnect	High Impedance
	Level	Bias	Bias	Bias	
Rx Output	Path	Enabled	Disconnected	Disconnect	High Impedance
	Level	Bias	Bias	Bias	
Tx Input	Path	Disconnected	Enabled	Enabled	High Impedance
	Level	Bias	Bias	Bias	
Tx Output	Path	Disconnected	Enabled	Disconnected	High Impedance
	Level	Bias	Bias	Bias	

Table 2. *Functions influencing signal paths.*

inversion circuitry is switched in and scrambling occurs. In this mode the balanced modulator carrier frequency values are determined by the split point address selected by pins A0 to A4.

ENABLE-MUTE

A low logic level applied to this pin disables the relevant tx or rx paths so that rolling code synchronisation information can be transmitted while maintaining internal bias conditions. In this mode, the receiver audio output is simultaneously removed, so muting the

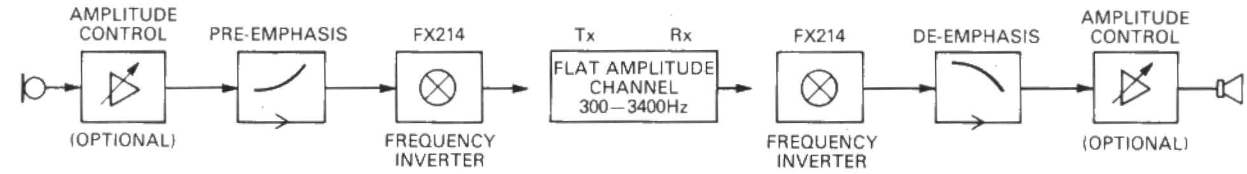


Fig. 5. *Recommended basic communications audio system layout.*

speech signal. A high logic level holds the circuit active during non-sync periods.

LOAD-LATCH

This pin controls the loading of the eight function inputs (Enable, Clear, Rx-Tx and A0-A4) into an internal register. With a high logic level on this pin, all eight inputs are transparent and the new data acts directly. When automatically controlled changing of the parameters is required the pin must be held low while the new function is loaded, and then taken high, followed by a return to low level. If latching of the data is not required this pin should be held high.

POWERSAVE

Pin 12, the around-through control, allows current consumption to be minimised if signals are being routed around the chip in a bypass mode. If signals are being routed through the chip, whether in clear or scramble mode, the pin is held low. If the signal is bypassing the chip, logic 1 applied to the pin puts the chip into a powersave condition in which all functions are shut down except for the oscillator circuit. In the powersave mode the signal input and output lines are made open circuit and are free from all bias. Table 2 includes this information in its functional logic data.

TRANSMIT INPUT

Pin 22 is the input to which the original speech signal is connected. It is held at a dc bias voltage level by an internal 300k resistor, consequently the pin must be capacitively coupled to the signal source. In the transmit mode the input is connected to the upper and lower band filters. The signal paths and bias levels are those given in Fig.3 and Table 2.

TRANSMIT OUTPUT

From pin 16 comes the processed audio signal, whether it is in clear or scramble mode. The pin is held at a dc bias level by an internal 100k resistor.

RECEIVE INPUT

Pin 18 is the input into which a received scrambled signal is fed for decoding. It is routed through the ctoss high pass filter in rx mode to remove sub-audio frequencies from the voice band. The internal circuitry reverses the inversion process used for transmission in accordance with the code selected by pins A0 to A4.

It is important to note that the correct descrambling will only take place if the coding of the transmitting scrambler matches that of the receiving scrambler. If different coding and decoding frequencies are selected then the final audio output will remain unscrambled. In practise it will probably be found that if the coding and decoding codes are closely associated, even if not fully matched, the resulting output signal may be partially comprehensible. Dc bias on this pin is applied by an internal 300k resistor necessitating signals to be capacitively coupled.

RECEIVE OUTPUT

The received and reprocessed signal is taken from pin 15 and is suitable for feeding to an audio output amplifier. It must be coupled via a capacitor to remove the dc bias applied by an internal 100k resistor.

VOLTAGE BIAS

All that pin 17 needs is an external decoupling capacitor to hold the bias voltage at half the power line level.

MODULATOR INPUTS

Pins 20 and 21 feed to the high and low band filter modulators respectfully and need to be connected capacitively to the corresponding filter outputs.

FILTER OUTPUTS

The outputs of the internal high and low band filters come from pins 19 and 23. As you will see from Figs.3 and 4 there are two filters associated with the low pass function, and the appropriate one is selected by the rx-tx input logic state. The rx-tx logic state also sets the high band filter, at 3.4kHz or 2.7kHz respectively. Both filter outputs must be connected to the respective modulator inputs via capacitors.

POWER SUPPLY

The chip needs to be run from a stabilised power supply of +5V. The current consumption is about 8mA in normal use, though this drops to 1.2mA if the powersave option is activated. Note that pin 14 must be left unconnected.

PRACTICAL CIRCUITS

Fig.5 shows the block diagram for an idealised basic audio scrambler system using additional pre- and de-emphasis to maintain good recovered speech quality. In the transmit mode pre-emphasis should not be given to the output of the scrambler, but in the receive mode de-emphasis should follow the scrambler.

If the system is to be used with a radio transmitter system having existing pre-emphasis circuitry it may be preferable to place an additional de-emphasis circuit after the transmission scrambler, as in Fig.6.

Providing signal levels are satisfactory, the basic chip circuit can be used on its own without additional on-board circuitry. To allow a little more flexibility in signal parameters Fig.7 shows a simple circuit that gives rudimentary conditioning to the input and output signals.

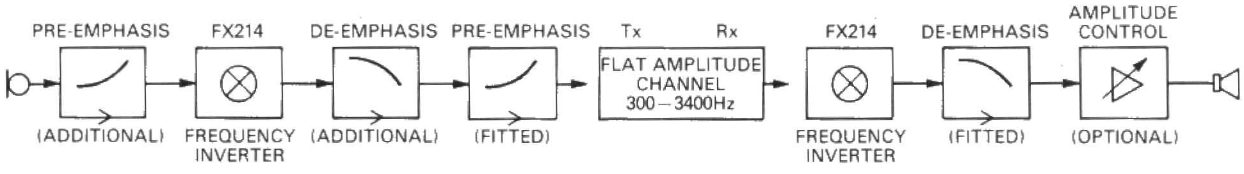


Fig. 6. *Recommended basic radio communicaton audio system layout.*

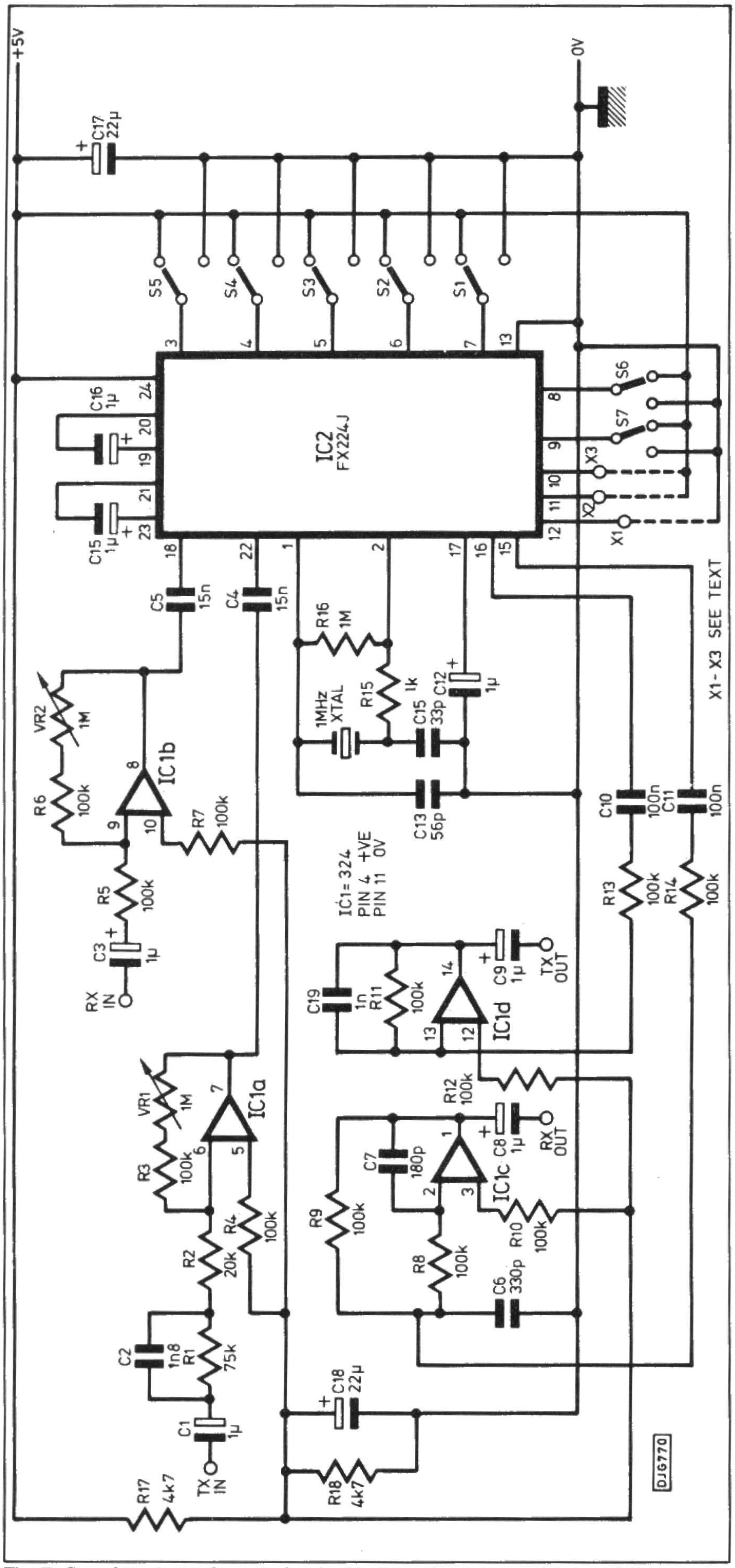


Fig. 7. *Complete circuit diagram for the 32-channel voice scrambler module.*

TRANSMISSION

The original signal to be transmitted is brought into the circuit around IC1a. Here pre-emphasis to the upper frequency levels is given by C2 in conjunction with R1 and R2. This helps to compensate for the upper frequency restriction imposed by the filtering within and after the scrambler. If it is not felt to be necessary, then omit C2.

VR1 permits the input gain to be varied between 1 and 100, so catering for a variety of signal levels. It is preferable, though, for the speech signal to have been previously preamplified to a reasonable level, of say, around 750mV rms. IC1d is simply a transmission output buffer at which signal de-emphasis can be applied by use of C19. It is not essential to use this capacitor and it may be omitted, or changed in value to suit individual needs.

RECEPTION

The received signal comes in to IC1b, at which point its level can be amplified by VR2 across a gain range of 1 to 100.

The unscrambled reception signal is buffered by IC1c and may be fed to any normal audio amplifier. Since the scrambler chip generates a certain amount of background noise due to its internal clocking functions simple high frequency filtering is provided by C6 and C7. The two FX224 chips used in the prototype produced about 10mV p-p of normal background noise. As long as the received input signal level is sufficiently high, the 10mV of noise is insignificant in this application, though the filtering around IC1c is worth including.

Of the functions available with the FX224 seven have been allowed for on the pcb. These are the five filter address code inputs, the scramble-clear input, and the transmit-receive control. If you intend to be more adventurous by using the other options available, access to their control pins is made at points X1 to X3, cutting the pcb tracks as necessary.

OSCILLATOR

The 1MHz oscillator is controlled by the crystal, R15, R16, C13 and C14. I carried out several tests varying the oscillator frequencies between two units coupled as transmitter and receiver, but found that precise setting of the frequency was unnecessary and so frequency trimming has not been designed in.

One reason why I carried out these tests was due to the characteristic mention earlier, that of adjacent frequency bands allowing partially unscrambled speech to be understandable even though the coding switches were at dissimilar settings. The accuracy of the clock frequencies made no difference and I concluded that the effect was due to the slope characteris-

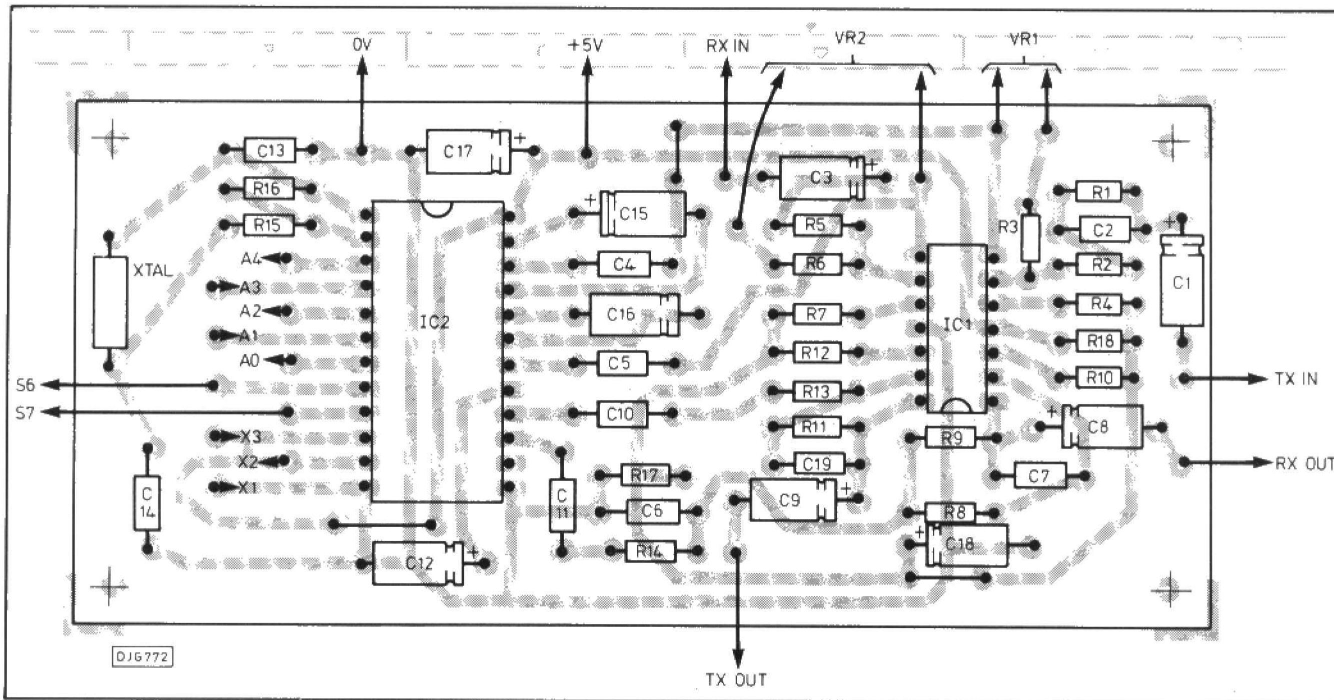


Fig. 8. *Printed circuit board details for the 32-channel voice scrambler module.*

tics of the internal selective filters. These are very tight in their pass bands, but adjacent bands are not totally isolated from each other, though their separation is sufficiently great for the chip designers to justifiably claim 32 channels of coding. Rest assured that if unscrambled speech signals are intercepted by eavesdroppers they are totally incoherent until fed into a descrambler.

ASSEMBLY

Fig.8 shows the pcb layout for a single scrambler module, with the wiring details shown in Fig.9. Before inserting the FX224 touch the conducting body of an earthed soldering iron to discharge static electricity from yourself since the chip is a cmos device. There is no alignment or setting up to be done.

For checking out the assembly two methods are possible. If you are only building one unit, plug the tx output into a cassette or tape recorder and record a message onto tape, switching the controls through their various permutations. Then play the recorded tape back through the rx circuit, switching the controls through the same permutations as before. This will confirm the effectiveness of the coding and decoding circuits.

Alternatively, if two modules are being built, intercouple them so that one is the transmitter and the other the receiver. Check out the switching functions, then swap the roles of the modules, and check out again.

APPLICATIONS

In theory the scramblers can be used in any situation where it is necessary to transmit and receive spoken messages which are of a confidential nature.

However, it must be remembered that in Britain there are restrictions to the use of scramblers, and to the use of equipment coupled to telephone lines.

In the first instance, scramblers are not allowed to be used with CB radio transmissions since the licence only permits the transmission of clear speech. It appears that licenced radio amateurs, or 'hams', are permitted to scramble their transmissions. Owners of mobile or cellular radio installations are also permitted to use scrambling (this is the manufacturer's primary intention for the FX224 and its siblings).

TELEPHONE USE

Much effort has been put into trying to find out from British Telecom what the situation is with regard to using scramblers on the telephone network. Despite contacting various departments the situation still is not clear. I believe though that certain conclusions can be drawn.

Firstly, I can think of no sensible reason for the prohibition of sending coded speech messages down a telephone line. If it is illegal to do so then I can only conclude that this is to make 'tapping' of telephone calls easier — a situation which would alarm anyone who respects his or her right to privacy. Secondly, we already know that the phone lines are used for data transmission in coded form, so it seems reasonable that speech may also be coded.

The main restriction to the use of scramblers on the phone lines would appear to be not because they are scramblers, but because they may be unauthorised equipment. It is quite

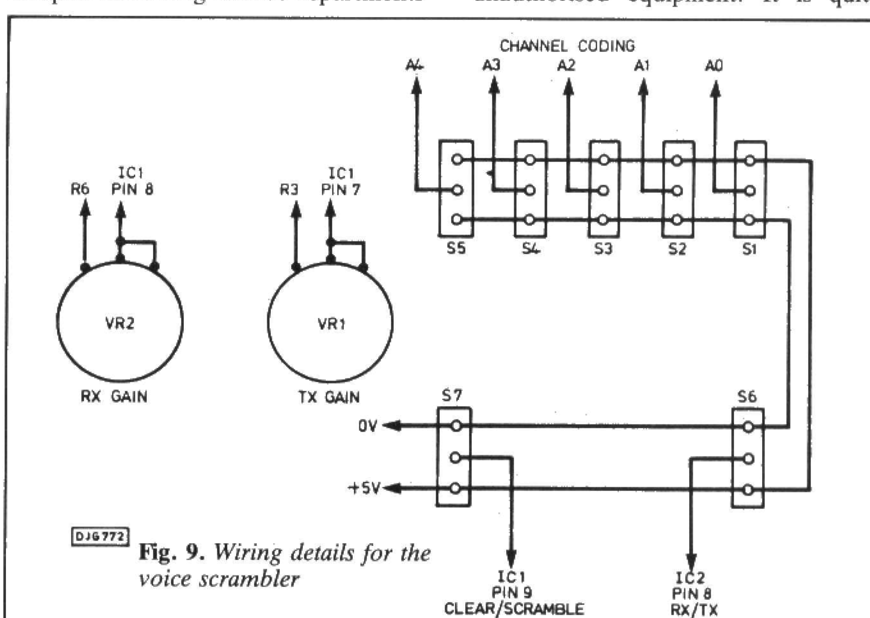


Fig. 9. *Wiring details for the voice scrambler*

understandable that Telecom should not wish unapproved electrical equipment to be put on their lines since any non-conformist or malfunctioning circuit could cause havoc to the system. In spite of efforts to find out what the specifications are for equipment that may be considered for approval, I have drawn a blank.

Therefore, if you intend to use the scramblers over the phone lines, I must emphasis that in no way should they be coupled in directly without official approval. Instead, I suggest that you consider modifying one of those auxiliary acoustic coupling units on which the phone handset is placed. These units allow the incoming speech to be heard through a loudspeaker, and for a microphone to pick up speech and play it into the handset mouthpiece. It should present no significant problem to find the best points to which the scrambler should be connected. If I were doing it I would probably try breaking in at the respective volume controls for the loudspeaker and the microphone circuit.

COMPONENTS

RESISTORS

R1	75k
R2	20k
R3–R14	100k (12 off)
R15	1k
R16	1M
R17,R18	4k7 (2 off)

All ¼W5% carbon film.

CAPACITORS

C1,C2,C8, C9,C12,C15, C16	1μF electrolytic (7 off)
C2	1n8 polystyrene
C4,C5	15n polyester
C6	330p polystyrene
C7	180p polystyrene
C10,C11	100n polyester (2 off)
C13	56p polystyrene
C14	33p polystyrene
C17,C18	22μF electrolytic (2 off)
C19	1n polystyrene (see text)

SEMICONDUCTORS

IC1	324
IC2	FX224J

POTENTIOMETERS

VR1,VR2	1M log rotary

MISCELLANEOUS

Pcb 287A, 14-pin ic socket, 24-pin ic socket, spst switches (7 off), 1MHz crystal, pcb clips (4 off), knobs (2 off), audio sockets to suit equipment (4 off).

CONSTRUCTOR'S NOTE

The FFX224J, scrambler pcb, and a full kit of parts are available from Phonosonics (see advert).

OTHER USES

The use of scramblers does not need to be restricted to telephone or radio transmission. Use with tape recorded messages is an equally valid function to which they can be put. You would simply record your scrambled message on to tape, and send it to your friend or colleague, who would then play it back through an equivalent scrambler. Naturally, both of you would have to establish a method by which the scrambling code could be known in advance of playback.

Musicians should also find amusement from playing their instruments through a single scrambler as some quite remarkable effects can be produced by the frequency inversions.

SPECS APPEAL

Finally, if the Telecom or DTI official responsible for specifications and approval of telephone coupled equipment should read this, please will you come out of hiding — PE would love to chat with you, in clear speech mode.

PE

TIME AND FREQUENCY MEASUREMENT

BY ANTHONY H. SMITH

PART ONE: THE UNIVERSAL COUNTER TIMER

The universal counter timer appeared as a piece of test equipment in the 1940s. Since then, the range of signal values which can be processed, the complexity of the processes and the ways in which they can be harnessed directly by external systems has expanded enormously. This first article in the series is an introduction to ucts and the ways in which they work.

The need to measure time and frequency is an age-old problem which has inspired the development of a varied assortment of techniques and devices with vastly differing degrees of accuracy and complexity. The earth's rotation, leaking buckets, burning candles, sand-filled hourglasses, swinging pendulums — these are all examples of our ancestors' attempts to quantify time.

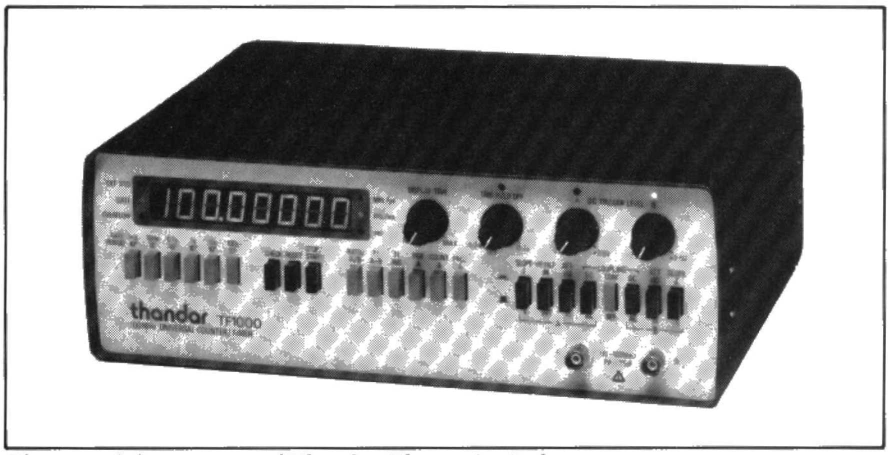
Nowadays, the atomic clock based on the caesium 133 atom establishes the standard of time — and its correlation, frequency — with an accuracy of one part in 10^{13}, ie, one part in ten million million! This staggering degree of precision is several orders of magnitude better than that associated with the measurement of any other physical quantity.

REALITIES

Quoting mind-boggling figures is all very well, of course, but making accurate measurements in practice is a little more difficult. Using suitable transducers, a broad spectrum of time-varying phenomena can be converted into various types of electrical signals. However, processing these signals in order to measure their time and frequency parameters requires a sophisticated piece of equipment. Ideally, we require an instrument which is straightforward to use, makes measurements as quickly as possible, and displays its reading in a precise, easily-interpreted, unambiguous form.

If the instrument is to be used in the field it must be both portable and rugged; it may also have to withstand extremes of temperature and humidity. In the laboratory, precision will be the major factor, and many modern instruments can achieve levels of accuracy approaching that of the caesium standard.

The list of demands made of the instrument could go on and on — but which kind of measurement system comes close to meeting these requirements?



Photograph by courtesy of Thandar Electronics Ltd.

UNIVERSAL COUNTER TIMER

In the vast field of test and measurement equipment, the universal Counter Timer (uct) is probably unique in its ability to measure, with unparalleled accuracy, a remarkable assortment of input signals, varying not only in amplitude (from a few millivolts to several hundred volts), but also in shape (from a simple sinusoid to a 'noisy', complex, irregular waveform).

However, the term "universal" applies not only to the uct's signal handling capabilities, but also embraces the many different *types* of measurement it can perform, such as frequency, period, time interval, pulse width, and so on. Furthermore, the uct is universal in its ability to measure a wide *range* of intervals and frequencies. Even the simplest models on the market can usually measure frequency up to 10MHz, and time down to a microsecond or less, whereas the more powerful (and more expensive) instruments can handle frequencies from zero to 50GHz ("dc to daylight"!) and can detect time periods as short as a few nanoseconds.

The versatility and sophistication of today's uct is quite impressive for an instrument which has been around for little more than thirty years.

The species first appeared in the late 1940s: the earliest types, crammed with scores of vacuum tubes, bore little resemblance to their present-day offspring, and were used simply to totalise random particle emissions in nuclear radiation experiments. Nevertheless, the potential for development was recognised, and in 1952, Hewlett-Packard introduced its first digital counter. This model, the HP524A, could measure frequency up to 10MHz, and time intervals with a resolution of 100ns; these specifications are still good, even by today's standards, and the HP524A was considered a milestone in electronic instrumentation.

The development of the transistor continued the evolution of the uct, and the advent of mos and lsi devices during the 1970s resulted in a range of instruments with increased performance and lower power consumption.

Lately, the microprocessor has accelerated the trend towards "counter intelligence", whereby ucts can do much more than simply measure time and frequency. The Philips PM6652, for example, employs two microprocessors, one to supervise front panel settings and to control system operation, the other to automate fast measurements and data handling.

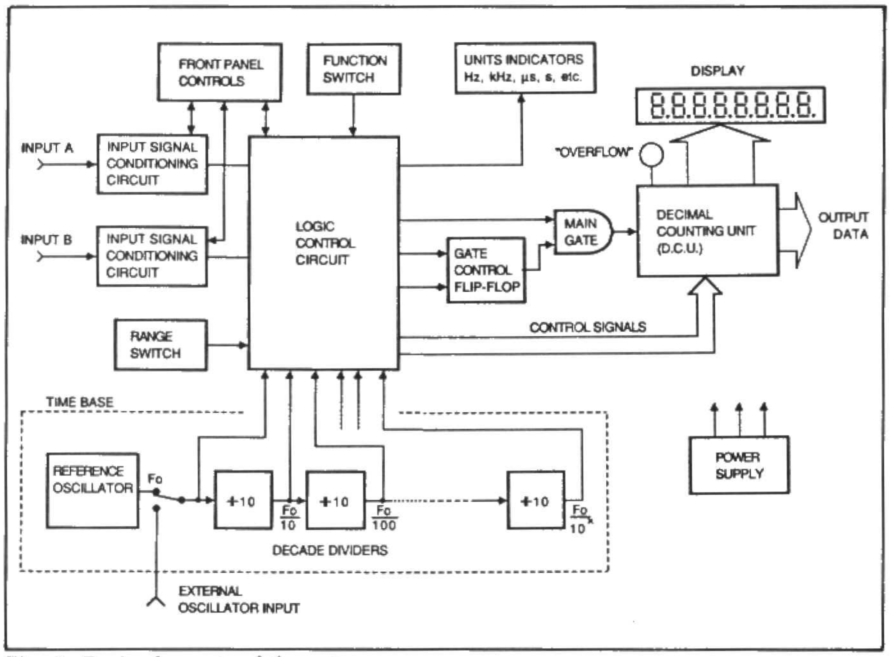


Fig. 1. *Basic elements of the uct.*

Vlsi processing power also enables many types of counter to converse with external systems: the PM6652 can be adapted to communicate, via the IEEE-488 bus, with computers, data retrieval equipment, telemetry systems, and so on.

It is obvious that from humble beginnings the uct has been transformed into an extremely versatile instrument. As well as the basic parameters of frequency and period, the uct can often measure additional parameters such as phase, frequency ratio, duty cycle, pulse transition time, and slew rate. Furthermore, "state-of-the-art" models offer many other features such as programmable operation, signal amplitude readout, trigger level display, maths facilities, hysteresis band compensation, and a wealth of other ingenious functions.

FUNDAMENTALS OF THE UCT

The basic elements of the uct are arranged as shown in Fig.1. With the exception of the input conditioning circuitry and the power supply, (and, perhaps, the reference oscillator), each section is made from digital components. These may be taken from the same logic family, or may be a mixture of types (such as cmos, ttl, ecl) in order to optimise the speed and power requirements for each particular element.

Two inputs are shown in the diagram; this is not always the case — many instruments have only one. However, when making frequency ratio-, phase-, or time interval measurements, two inputs are obviously essential. Furthermore, two inputs allow for easy comparison of signals from different sources: for example, the period of signal A could be rapidly compared with the pulse width of signal B simply by operating the function switch.

Many ucts provide a third input, although this is often reserved for measurements on vhf signals.

SIGNAL SHAPING

The input signals themselves may be derived from a variety of sources, and may be of any amplitude and waveshape. However, since the uct can process only digital signals, the input conditioning circuit is essential for converting the inputs to digital form; it must also be capable of removing the effects of noise and modulation which would otherwise distort the reading.

The operation of this conditioning circuitry will be described in detail in a later article. Note, however, that the sophistication of the input circuits often dictates the overall accuracy of the measurements: if the uct is missing input cycles, or is triggering on the wrong part of the waveform, then the reading will inevitably be in error.

CONTROL CIRCUITS

The logic control circuit is a collection of gates, flip-flops and multiplexers responsible for routing the appropriate signals, via the main gate, to the decimal counting unit; the actual signal counted depends on the particular function and range selected.

The control circuit also supervises the operation of the decimal counting unit, and is responsible for illuminating the appropriate units indicator, along with the correct decimal point. Synchronisation of all these functions is provided by signals derived from the time base.

THE MAIN GATE

Whereas the control logic determines *which* pulses are counted, it is the task of the main gate, governed by the gate control flip-flop, to determine *when*, and for *how long*, the pulses are counted.

The main gate is essentially a two-input AND gate: a logic high from the control flip-flop opens the gate and allows pulses to be counted. The flip-flop itself is controlled by one or both of the input signals, or by the time base, depending on the type of the measurement being made.

Since all counted pulses go via the main gate, its maximum operating frequency places a restriction on the upper frequency limit of the uct itself: ttl or hcmos devices may allow operation up to 40MHz or so, whereas ecl types can work up to 500MHz, or beyond.

THE TIME BASE

In the measurement of any physical quantity, we require some kind of "standard" with which to compare the unknown quantity. In the uct, this "yardstick" is the time base, which provides precise reference frequencies and time periods.

Central to the time base is the reference oscillator, whose output is a digital pulse train having a typical frequency, F_o, of 10MHz. This is fed to a series of decade dividers, such that the time base output is a decade range of frequencies from 10MHz down to 1Hz or less; one of these outputs is selected by means of the range switch to provide the desired scaling-factor for a particular measurement.

The integrity of the measurement depends on the accuracy and stability of the reference oscillator, and for most purposes, the ubiquitous quartz crystal oscillator is more than adequate. However, even the quartz oscillator has limitations and many ucts have an external oscillator input, whereby the internal oscillator can be substituted by an external standard of better quality.

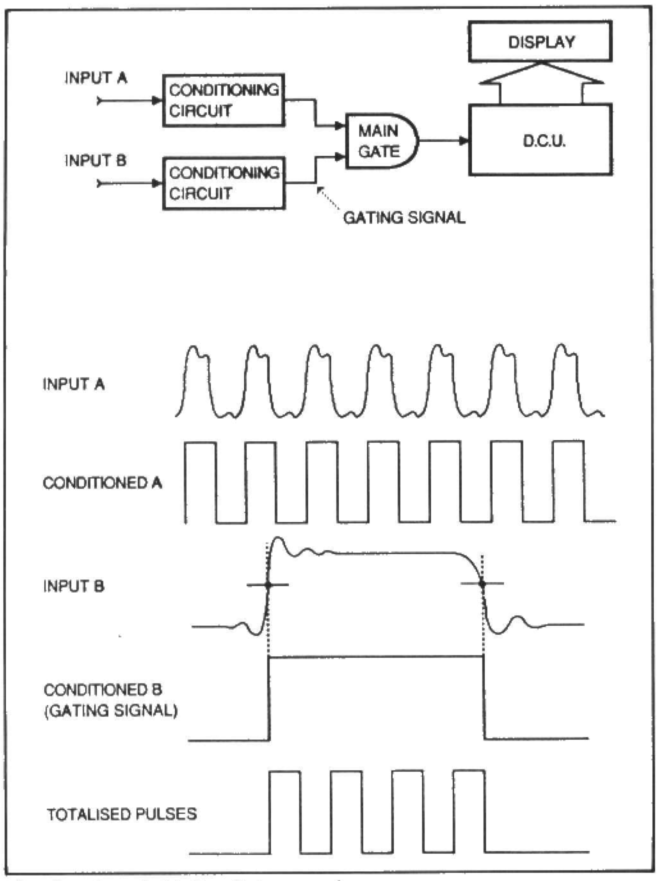
PULSE COUNTING

At the heart of the uct is the decimal counting unit (dcu), responsible for counting-up the pulses output from the main gate. The dcu comprises a chain of cascaded decade counters: the numerical content of each counter is displayed on the corresponding digit in the uct's readout.

Before beginning a measurement, the logic control circuit sends a reset pulse to the dcu which sets all the internal counters to zero. Each pulse is then counted, one by one, until the measurement is over; the total number of pulses accumulated is then indicated, in decimal form, on the digital display.

If too many pulses are received during a particular measurement, the dcu will "spill over"; consequently, the displayed reading is invalidated, and an overflow indicator is usually provided to warn of this condition.

In addition to driving the display, the dcu may also output the reading in a multiplexed bcd format. This word-serial, bit-parallel information can be used to drive printers, digital-to-



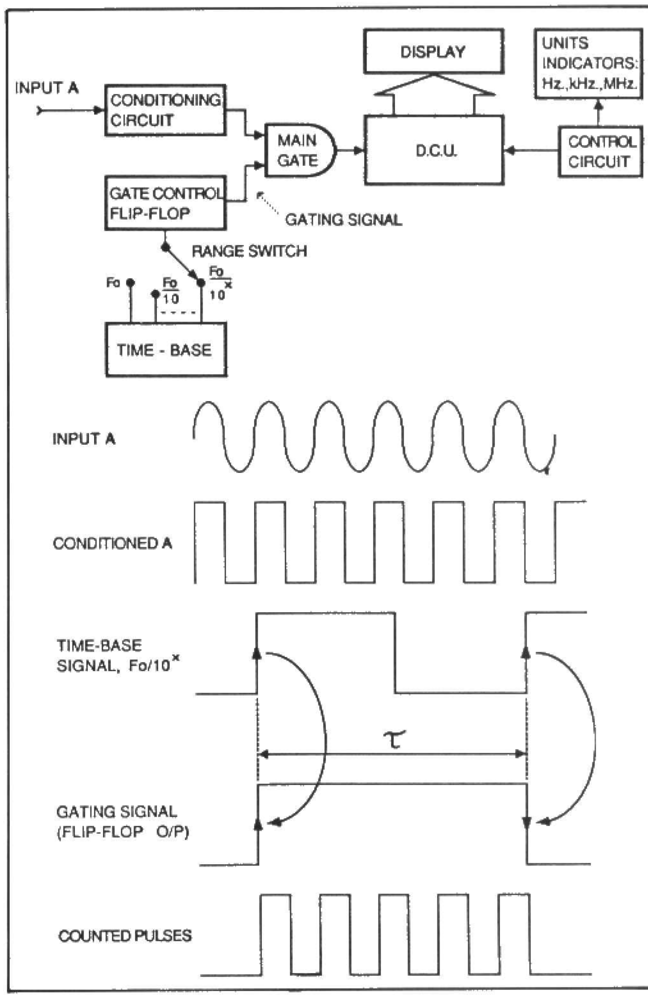


Fig. 2a. *(top left) Totalising mode*
Fig. 2b. *(bottom left) Totalising mode example timing diagram*
Fig. 3a. *(top right) Frequency measurement*
Fig. 3b. *(bottom right) Timing diagram frequency measurement*

analogue converters, or computer interfaces.

THE DISPLAY

The number of digits in the display is determined to some extent by the "gate time", (when measuring frequency), and by the time base reference frequency, (when measuring time), since both these factors determine the resolution of the measurement.

However, a more significant restriction derives from the reference oscillator, where the limits of accuracy and stability simply cannot justify having too many digits. For example, there is little point in resolving a measurement to ten significant figures if the oscillator frequency itself is only accurate to eight significant figures. Similarly, there is nothing to be gained in using a long gate time to increase the resolution of a frequency measurement if the frequency of the reference oscillator is likely to drift somewhat during this period.

Consequently, the accuracy of the common-or-garden quartz oscillator usually limits the number of meaningful digits to seven or eight.

MEASUREMENT CONCEPTS

Part of the versatility of the uct lies in its ability to use the same fundamental elements to achieve a variety of different measurements. The operation of each element remains virtually the same for each type of measurement: it is only the various signal paths which are changed.

TOTALISING MODE

The totalising mode (sometimes called "units counting" or "events counting" mode) is used to count up the number of times an electrical event takes place (eg: the closing of a switch, the pulses output from a light sensor, etc).

The uct elements are connected as shown in Fig.2a, where the events to be totalised are applied to input A; the signal at input B is a gating signal used to control the main gate. From the timing diagram of Fig.2b, we see that the pulses at A are only totalised for the duration of the signal at B. Consequently, the reading displayed represents the number of events occurring during this time; all others are ignored.

This ability to control which pulses are counted is not available on all ucts: several models derive the gating signal from a front panel switch, whereas others leave the gate continually open, such that the dcu accumulates all the input pulses until reset by the operator.

Certain models offer variations on the theme: for example, the Hewlett-Packard HP5345A counts the pulses occurring at both input A and input B, and can then display the value of either (A+B) or (A−B).

FREQUENCY MEASUREMENT

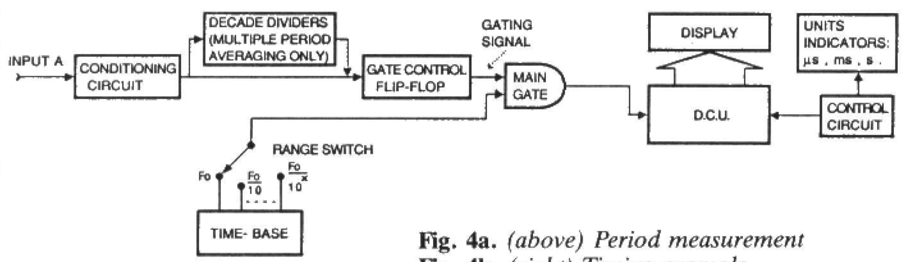
The circuit used to measure frequency is a simple extension of the totalising circuit, and is shown in Fig.3a. Note that the gating signal is now derived from the time base, rather than from an external signal.

The definition of frequency is simply "the number of cycles occurring during unit time", ie, the number of cycles per second. Thus, if the main gate is opened for exactly one second, the number of pulses counted will be the frequency, in Hertz, of the signal at A.

The timing diagram of Fig.3b shows that the gate control flip-flop is operated in toggle mode, such that the main gate is opened for a gate time, τ, equal to the period of the selected time base signal. In this example, five pulses are counted, and so if τ = one second, (ie, if the time base reference frequency is 1Hz), then the input frequency is 5Hz.

One might assume that the definition of frequency would limit the gate time, τ, to one second only. However, other gate times can be used, provided the display is modified accordingly.

For example, consider an input frequency of 7654321Hz: with a one second gate time and an eight digit readout, this will be displayed as 07654321. Hz, (or as 07654.321kHz). If the gate time is now reduced to, say, one millisecond, (by selecting a 1kHz reference frequency),



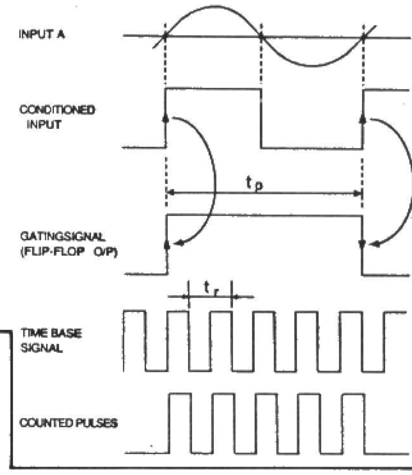


Fig. 4a. *(above) Period measurement*
Fig. 4b. *(right) Timing example*

then the number of pulses accumulated will be a factor of a thousand less, ie, only 7654 cycles will be counted. However, this can still be displayed — quite correctly — as 00007654.kHz.

Short gate times allow us to make quick measurements — for example, when following rapid changes in the input frequency. Note, however, that there is a corresponding reduction in measurement resolution.

It follows, then, that to *increase* resolution we simply increase the gate time. If an input frequency of, say, 123.45Hz is counted for a gate time of 100 seconds, the dcu will accumulate 12345 pulses: with appropriate decimal point selection this reading can be displayed as 000123.45Hz. Obviously, the resolution is 100 times greater than that obtained if a one second gate time is used; however, limitations due to the reference oscillator stability and measurement speed usually dictate that gate times greater than ten seconds are rarely used.

PERIOD MEASUREMENT

Fig.4a represents the circuit used to measure the period of input A. The arrangement is the same as that used to measure frequency, but with the main gate inputs interchanged (compare the relative positions of the gate control flip-flop). In other words, the input signal itself now provides the gating signal, whereas the pulses counted by the dcu are derived from the time base. The reciprocal nature of the two circuits is not really surprising, since the period of a signal is simply the reciprocal of its frequency.

Once again, the gate control flip-flop is operated in toggle mode, such that the width of its output pulse is equal to the period of the input signal, t_p. This is illustrated in Fig.4b.

Each of the time base pulses counted during t_p corresponds to a precise time period, t_r (a certain multiple of the reference oscillator period). The magnitude of the input period is thus:

input period, $t_p = n.t_r$,

where n is the number of pulses counted.

For example, assume the range switch selects a reference frequency of 1MHz, such that t_r = one microsecond. If the dcu accumlates, say, one million pulses, then $t_p = 10^6 \times 1\mu s = 1$ second. The reading will be displayed as 01000000.μs, or 01000.000ms, or 01.000000s, depending on the uct used.

Unlike frequency measurement, the resolution of the reading depends not on the gate time (which is now determined solely by the input period), but instead on the magnitude of t_r. Each of these periods forms a quantum of time — the smaller these quanta, the more are counted during a given input period, and the greater is the resolution of the reading.

For the one second period considered previously, using a reference frequency of 10MHz (such that t_r = 100ns), instead of 1MHz, would allow the dcu to accumulate ten million pulses, resulting in a reading of 1000000.0μs, ie, a resolution of 0.1μs rather than 1μs.

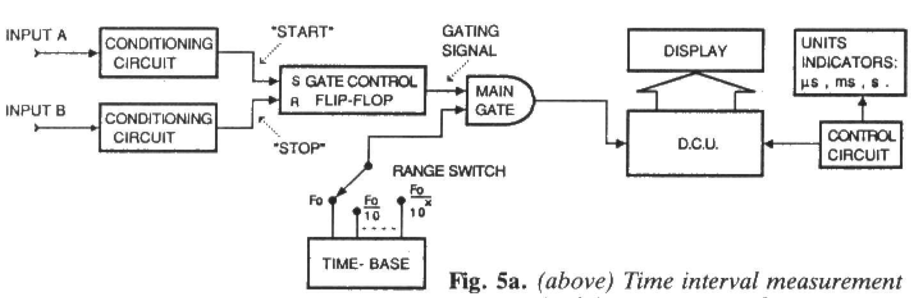
It might appear that we should always select the highest time base frequency in order to get the best resolution. However, when measuring an input signal with a very long period, it is necessary to increase t_r (ie, select a lower time base frequency) simply to prevent the dcu overflowing. For example, if the counter has an eight digit display, selecting the 10MHz time base signal will allow a maximum period of ten seconds (actually, 9.9999999 seconds) to be displayed. On the other hand, a 1kHz time base signal would allow a period of 100,000 seconds (27.8 hours!) to be displayed using the same eight digits.

The resolution can be increased still further by the use of multiple period averaging. This powerful technique (described later) involves averaging the reading over a large number of input cycles, and can be applied equally well to time interval measurements, and frequency ratio measurements.

TIME INTERVAL MEASUREMENT

When in time interval mode, the uct behaves like a stopwatch, in that it measures the elapsed time between two electrical events. The block diagram is shown in Fig.5a, where the signal at input A starts the measurement, and that at B stops it.

The conditioned signals from each channel are fed to the gate control flip-flop, which essentially acts as an S-R latch. This is illustrated in Fig.5b, where the start signal from channel A sets the flip-flop, and the stop signal from channel B resets it. Consequently, the



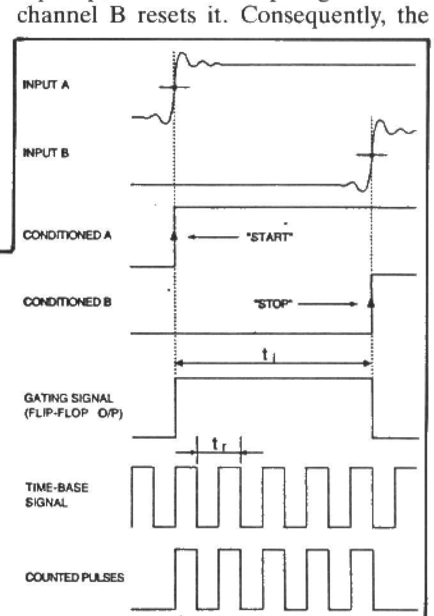


Fig. 5a. *(above) Time interval measurement*
Fig. 5b. *(right) Timing example*

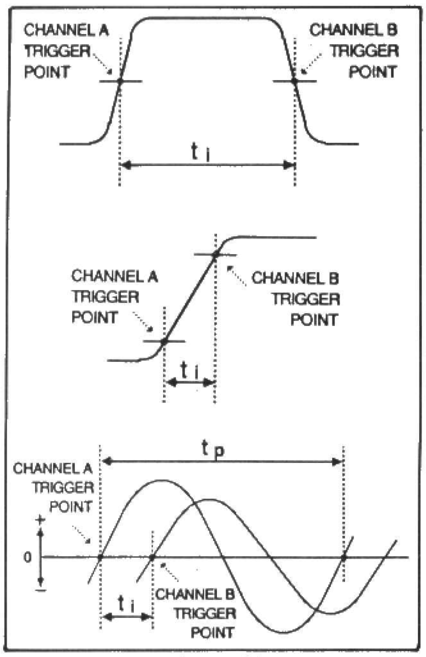


Fig. 5c. *(top) Pulse width measurement*
Fig. 5d. *(middle) Transition time measurement*
Fig. 5e. *(bottom) Transition time measurement*

length of the gating signal, t_i, is equal to the time interval between the input signals; during this time, the dcu counts the reference pulses in exactly the same way as for a period measurement.

In addition to measuring the time between two completely separate signals, the time interval mode can be used to measure the interval between different points on the same waveform. This is achieved using the input conditioning controls, in particular the trigger level and slope controls, to set different trigger points.

For example, Fig.5c shows channel A set to trigger on the positive slope, and channel B set to trigger on the negative slope, such that the time interval measured is effectively the *width* of the input pulse.

Fig.5d, on the other hand, shows both channels set to trigger on the positive slope, but at different voltage levels. The result is a measurement of the *rise time* of the signal.

The time interval mode is necessary when measuring the phase of two signals, as shown in Fig.5e.

Channel A triggers as the leading signal passes through zero; channel B then triggers on the zero-crossing of the lagging signal. The period of either signal is measured next, and the phase difference is given by:

$$\text{Phase (in degrees)} = (t_i/t_p) \times 360.$$

The only requirements for an accurate measurement are that the trigger points be set correctly, and that the signals have the same frequency. Several ucts, such as the Philips PM6652 and the Hewlett-Packard HP5335A, perform the phase measurement automatically, and display the phase directly in degrees.

FREQUENCY RATIO MEASUREMENT

The ratio of two frequencies is often a useful parameter: for example, when comparing the performance of two oscillators, or when checking the operation of frequency dividers and multipliers. Similarly, by using suitable transducers, it is possible to determine the gear ratio or clutch slippage of a piece of machinery.

The circuit arrangement used for the ratio mode is shown in Fig.6a. The higher-frequency signal is applied to input A, whereas the lower-frequency signal at input B is used as the reference signal. Consequently, the operation is similar to the frequency mode, but with input B providing the time base signal.

The ratio of the two frequencies is given by:

$$\frac{\text{frequency A}}{\text{frequency B}} = \frac{\text{(cycles of A)/second}}{\text{(cycles of B)/second}} = \frac{\text{cycles of A}}{\text{cycles of B}}$$

Thus, the ratio is determined by counting the number of cycles at A occurring during one cycle at B: this is shown in Fig.6b. Note how the main gate is held open for the duration of the period of input B. In this respect, the ratio mode is a versatile extension of the totalising mode: the first pulse at input B opens the gate and initiates the count, the second pulse closes the gate and completes the count.

The ratio mode is particularly useful when making "rate" measurements. These measurements allow quantities such as gallons per minute or miles per hour to be displayed directly. For example, if the period of signal B is fixed at sixty seconds, the output from a transducer connected to input A can be displayed directly in revolutions per minute.

MULTIPLE PERIOD AVERAGING

In the discussion of period measurement we saw that the resolution is determined by the time base frequency; for example, using a 10MHz clock provides for a resolution of 100ns. Consequently, it would seem that the only way to increase the resolution still further is to use a higher-frequency clock, and indeed, for one-shot measurements, (ie, measurements on a single cycle), this is quite true.

However, for repetitive signals, multiple period averaging can increase the resolution to one nanosecond or less, while still using the same 10MHz clock.

Consider, for example, an input period of 65.432μs: with a 10MHz time base frequency, 654 reference pulses would be counted during the gate time (ie, during the input period), and the displayed reading would be 65.4μs. If, now, the gate is held open for 100 input cycles, the gate time is increased to 6543.2μs, causing 65,432 pulses to be counted: with appropriate decimal point selection, this can be displayed as 65.432μs. Obviously, the resolution is increased a hundredfold; in general, the resolution is increased by a factor N, where N is the number of periods averaged out in this way.

This technique can be implemented simply by adding a series of decade dividers to the basic period measurement circuit — see Fig.4a. A single divider causes the input frequency to be divided by ten, ie, the input period is increased by a factor of ten, as is the resolution. Obviously, two dividers will increase the resolution a hundredfold, three will increase it a thousandfold, and so on.

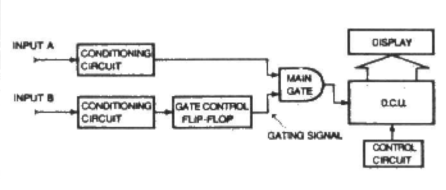
Multiple period averaging is useful not only for increasing the resolution of a measurement, but also for reducing the associated errors, and similar techniques can benefit the measurement of time interval and frequency ratio. However, there are specific requirements which must be met if the averaging method is to be applied correctly, and these will be discussed in a later article which deals with sources of measurement error.

ADDITIONAL CONTROLS AND AIDS TO MEASUREMENT

A variety of controls and indicators is available on many ucts to enhance the basic operation.

A typical example is the "hold" button; when pressed, this suspends the measurement operation, and freezes the display at its current reading.

The "reset" button, on the other hand, clears the display and resets all internal circuitry so that a new measurement can be started immediately. Certain models provide



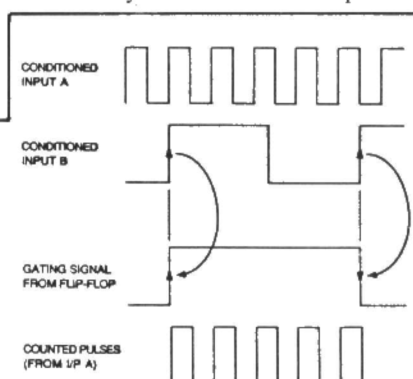


Fig. 6a. *(above) Frequency ratio mode*
Fig. 6b. *(right) Signal relationship, ratio mode*

external hold and reset inputs so that they can be operated by a remote contact closure, or by a suitable electri-cal signal.

The "one-shot", or single measurement, facility is a useful extension of the hold control. When in one-shot mode, the uct automatically goes on hold after the main gate has closed (ie, after a single measurement), such that any subse-quent changes in the input parameters will not affect the reading.

Many ucts provide various forms of feedback. A typical example, usually found on the more expensive models, is the provision of start/stop markers. These outputs are narrow pulses corresponding to the opening and closing of the main gate, and can be used to intensity-modulate an oscilloscope trace of the input signal; the markers show up as bright spots on the waveform, enabling the operator to set the trigger points correctly.

Sometimes, the output of the gate control flip-flop is made available for similar purposes. Alternatively, this signal may be used to drive a front panel led, usually labelled "measurement in progress", or simply "gate open".

Similar types of feedback are provided by the input conditioning circuitry: these will be described, along with the circuitry itself, in part two, next month.

PE

PE BAZAAR

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DAT'S PROGRESS

By Wayne Green — Renowned US Publisher and Author

DIGITAL AUDIO TAPE GETS A HEARING

What happens when you cut a notch in something? It makes it weaker. This technique, aimed at dat, has boomeranged on its devisors.

Dr Wayne Green is the renowned US author, publisher and founder of over 50 computer and technology magazines, including Byte and Microcomputing. He recently stood as a vice-presidential candidate in the US primary elections.

The rhetoric has been fun, with the Recording Industry (RIAA) on one side pumping up a molehill into Mt Fuji proportions and the Big Japanese electronic firms, all of whom have dat recorders poised for shipment to the US, genuflecting toward congress.

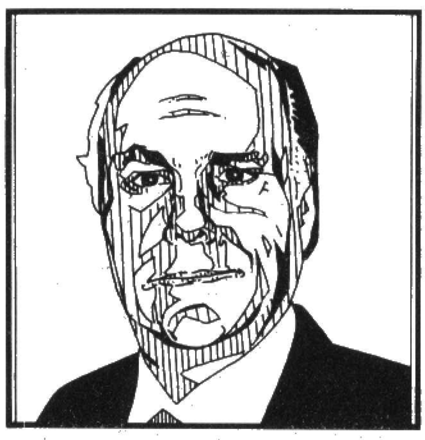
WINDY BLATHERS

The blather has been particularly windy over the CBS copy code — the sound notch CBS proposed removing from cds (and all other recorded music, by the way) in order to trigger dat recorders into paralysis, thus preventing consumers from making digital copies of anything for use in cars — thereby impoverishing the record industry.

The hardware people warned that the proposed notch would be audible and would thus ruin the perfection of cds. CBS said flatly that their notch would be totally undetectable. CBS also claimed the notch would not fail to stop copying — and that the notch-sensing circuit would never prevent un-notched material from being taped. They also claimed their system would be difficult and expensive to defeat.

Having worked extensively with notch circuits, I challenged CBS on all counts. It didn't make engineering sense to me to be able to slice a notch of sound from a cd without introducing distortion. Filters do that — fact of life. I also doubted that the notch-sensing circuit wouldn't default on many normal cds.

Congress, unable to deal with anything as technical as this, turned to the National Bureau of Standards (NBS) for a test and report on the CBS notch. This had the advantage of putting off any decisions for a few months, thus allowing congress to get the benefit of a few more months of lobbyist attention, from both sides.



NO NOTCH SCOTCH

When Sony, the chief opponent of the notch, bought CBS, that seemed like a neat solution. Sony announced that the CBS acquisition absolutely positively wouldn't influence the notch project. Sure.

NBS released their report on March the first — should have been a month later by rights. They found the CBS notch system to be defective on every claimed point. Their tests showed that dat recorders sometimes refused to copy uncoded sound — that they sometimes were able to copy encoded sound — that listeners could indeed hear the difference when music was notched — and that circuits to defeat the notch were simple and inexpensive to build. It would appear that the CBS notch was more a product of their PR department than their engineering. NBS shot the whole CBS notch scheme down in flames.

Meanwhile, I'd sent copies of a compromise plan for a two-year test to every dat manufacturer and every music company. The results of that survey have been most gratifying. The opinions have run 93% in favour of the compromise. I'm checking with the few who voted against it to see if they actually read the proposal. The two I've reached so far changed their vote when I explained my proposal, which they apparently hadn't bothered to read.

Meanwhile the barrage of press releases and lobbying goes on, with threats from RIAA that they will sue any firm importing dat recorders. Just what we need, the threat of legal harrassment.

INFORDATION

In the meantime we're beginning to see some dat activity. Ford has announced the availability of a dat player for their Lincoln. GM, not to be left behind by Ford technology — at least when it comes to their entertainment accessories — is planning a dat player option for some Cadillacs. Dat players are okay by RIAA, since they can't record.

Some smaller labels are already starting to issue dat versions of their cds. I've three in hand from Folk Era and two from Capriccio so far. No, there's no market for the tapes yet, it's more a matter of prestige than marketing acumen.

MINI DIGIS

The three-inch mini-cds are pouring onto the market from several labels. These little discs hold about 20 minutes of music — the digital version of the old (dying) 45 single. The rationalisation for these has been the need for a less expensive, shorter disc with which to convince the kids to go digital.

Well, that's the cover story — the reality so far has been quite different. I've already got a couple of dozen minis

and they're all either classical or jazz. So where are the rock minis?

We're a bit short on three-inch players too. Sony showed some prototypes at CES in January, but I haven't seen a production unit yet. That means I have to carefully snap the little discs into a flimsy plastic ring which makes it look like a five-inch cd to my players. Some players are harder to fool than others, adding a further obstacle to their success. I've got one top rated player which almost refuses to recognise minis.

By the time I add up the aggravations: difficult to mount, touchy to play, awfully short and there being no storage boxes which are compatible with cds, my minis are virtual orphans. Is this another product looking for a market?

SHORT SIGHTED

The industry came out with cd video (cdv) last year. Five minutes of video and 20-minutes of digital sound. So far no one has discovered any practical use for this marvellous technology. I suggested they might see if there is a consumer need for five-minute condensed versions of Swan Lake and Sleeping Beauty. Duck Pond and Napping Beauty maybe.

How can supposedly intelligent marketing people encourage their firms to spend the millions it takes to develop and introduce such a product — with no perceivable market for it? Well, perhaps they were attracted by the popularity of music tv (mtv). Bad timing since mtv has been losing ground in recent months.

Of the three new technologies, I'd say dat has the edge — but only if the industry can get the RIAA off its back and start bringing in dat recorders with no technological hobbles. No notches. No copy-preventing coding. No incompatible sampling rates. With no interference it's possible dat can make it.

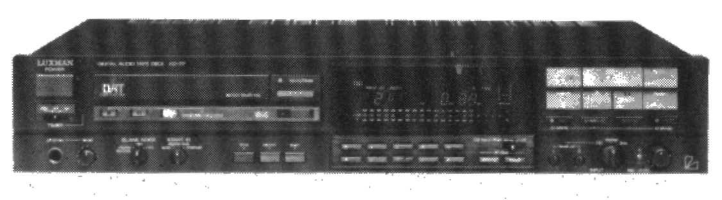
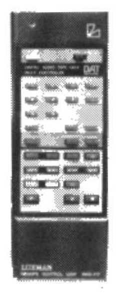
The dat technology is such that we're not going to be seeing inexpensive recorders for quite some time. The first units are expected to run around $2,000 or so. And since there are so few home applications where the benefits of digital sound over a first rate cassette recorder are actually needed, it could take a long time to build much of a user base.

BANDOLERO

I've had a dat recorder for a year now and, other than reviewing the recent pre-recorded dat tapes, I've only had two occasions to use it. One was to tape a local town band so I could make superb quality analogue cassettes for them from the digital master — the other to record some synthesised music from one of my wife's video tapes. She's got 22 how-to-dance videos and now is producing a series on how to use makeup to hide facial blemishes.

For most applications I use one of my cassette recorders and don't bother with the big dat system and its very expensive blank tape. We'll see how typical I am when dat systems become available. I notice their sales in Europe and Japan are very slow, so perhaps my experience is common. PE

Luxman have no doubt about DAT's progress. This is their KD 117 DAT player and is distributed by HW International. Tel: 01-609 0293.

THE INTELLIGENT WAY AHEAD

BY SIR CLIVE SINCLAIR

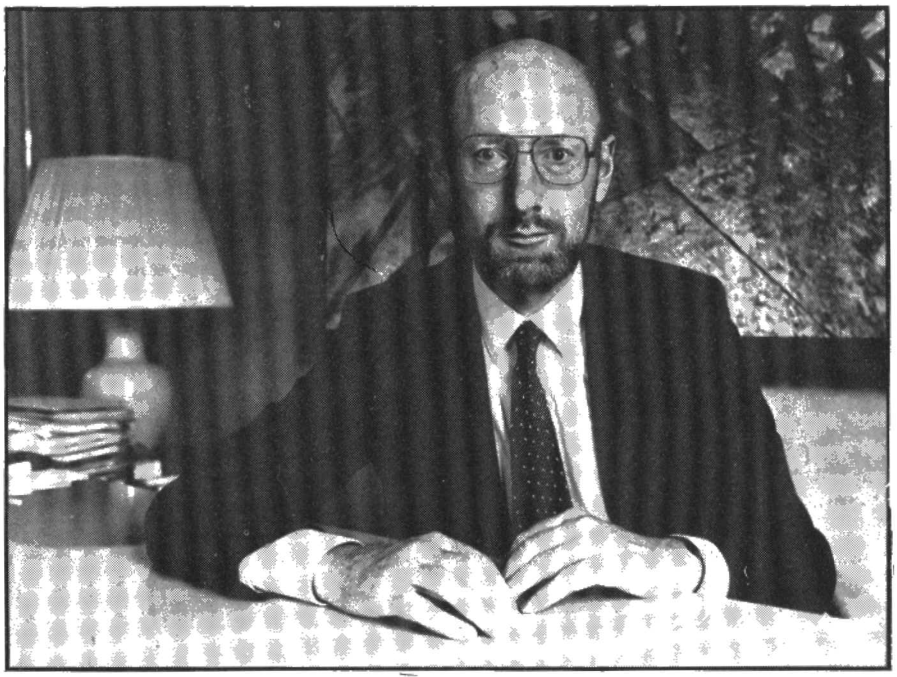
THE FUTURE OF PARALLEL RISC

Sir Clive Sinclair, affectionately known as The Entrepreneur's Inventor, took a look at the future of computing technology in his speech at the recent RITA (Recognition of Information Technology Achievement) Awards. We know you will be interested in what he said.

My Lords, Ladies and Gentlemen, when asked to give this little talk, and reflect on the future of personal computers, it was in the hope that I know all about it! I am reminded, unfortunately, of a friend of mine who said that the long term planning in the personal computer business is "what's for lunch?".

In order to look at the future, we've got to look a little at the past. The personal computer industry started, as I see it, in the late 70s when the 8-bit processor was the rule; the 6502, the Z80 and 60800. The people who led the industry then were Commodore and Radioshack – Tandy.

In the early 80s the 16 bit chips came along and we saw domination in the industry by the 80808 or 80806 and the 68000. The good companies then in dominance were IBM and Apple. Now in the late 80s we see the beginning of the 32 bit era with the 80386 and the 68030. And again, for the moment anyway, we have IBM and Apple and it would be comforting to think that that pattern will continue.



RISC ARCHITECTURE

It would be nice to be able to suggest that we'll continue on the same sort of path, and that the two major 32 bit chips will dominate. I don't think it will be quite like that. There are two big changes which are occurring in the industry at the moment which I believe are of great consequence. The first of these is the evolution of the risc architecture – reduced restriction set architecture.

Now these chips have appeared quite suddenly from several sources, though the idea is fairly old. The principle of the idea is that, if you examine how a computer works, and how it is normally used, of the many hundreds of instructions the normal processor has, only a very few of these will be used frequently; most of them will only be used infrequently. The idea behind risc architecture is that you design a chip so that it only has those frequently used instructions and the rest are synthesised from them. Because you've now only got a few instructions you can make a chip run those instructions very rapidly, indeed if you have done the job properly you have one instruction per block title.

This produces a chip that is hugely faster and ironically rather simpler to produce than the previous system chips and several companies, Acorn and NMOS in the United Kingdom, Sun in the States with their Spark chip (who've recently linked up with AT&T), and Lynx chips, and Fairchild, have all produced risc chips. The interesting thing about these is that because of their enormous speed they can actually emulate the key current chips of this industry and still run at a decent speed. That is to say, they can appear to be other sorts of chips and that is, I think, going to make a big difference because it is going to remove the near monopoly position of firms like Intel, who no doubt deserve their success, but it has given them a hugely powerful position.

So the risc chips come along and they give us perhaps, something like a factor of 10 improvement in an overall performance which is in itself very significant. But there's another even more significant change which is occuring and that is the move away from single processor architectures to parallel processor architectures.

UNKNOWN TERRITORY

The architecture that we use in computers today was proposed in the early 40s by John von Neumann and has been used pretty much universally ever since. As we move in to the parallel architectural field we are going into unknown territory and to some extent may have to part from the von Neumann approach and that is very disturbing.

Many gurus in industry have

suggested as a result that in fact this is entirely wrong, that we can always do everything we need to do with single processors just by making them faster and faster. The simple truth is that they've already reached what is probably coming very close to the limiting speeds of the single processor, and willy nilly, we're going on with the parallel track, and we're going along it in many different ways.

As I say, it is unknown territory and we have great supercomputer companies going for what is termed a coarse-grained architecture (that is to say, using a few very powerful processors). The companies at the machine's end will, I think, go in for fine-grained architecture and have no less than 65,000 processors in one machine. A fine-grained architecture processor is on its own very small and insignificant but grouped together very powerful indeed.

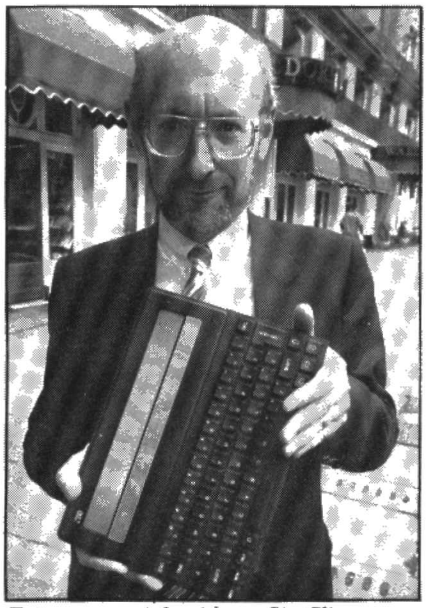
From these various approaches will emerge, I believe, something of huge significance and with regards to whichever route we take exactly, we know straight away that multiple processor architectures are giving us another factor of 10 improvement in performance and promise a factor of 100 or maybe 1000 in the very near future.

PROGRESSION OF WEALTH

Now, do we need and can we use this huge leap? I think that we can, very much so, and I'd like to digress slightly just to point out where we have been in this last 150 years in the West. We've seen over that period a pretty steady increase in wealth. Obviously the odd war has intervened, the odd recession, but generally speaking for that long period wealth has steadily improved.

First of all we have increased our wealth by taking people from the land and putting them into industry. We were able to do this because we had found better ways of organising our agriculture. That came to an end and pretty much exhausted the people on the land. We then increased our wealth by reducing the number of people required to produce the products. That too is coming to an end. We have now only 20% of our working population in industry. By the early part of the next decade that'll be down to perhaps 10%. We can't then expect to increase our wealth very much more by taking people out of industry and putting them into services. Those fewer people who are producing all the goods that we realistically need, won't need to produce any more goods. What we need to become wealthier is more doctors, more nurses, more policemen perhaps, more people in the services in general, and there is no way in which we can just conjure those out of the blue.

And so, if we are to increase our wealth towards the end of this century



Entrepreneurial pride — Sir Clive Sinclair with the new Z88

and the early part of the next century, we have no choice but to replace men's intelligence, much as in the past we have replaced men's strength. That is where these chips come into their own, because what we can do with these technologies is begin to move into artificial intelligence. The first example of this we will see, is machines that we can talk to in real time and they will understand us. I don't believe that is as far as many might think. I certainly think it is no more than 20 years away and probably only 10 years away. It will be a rather startling development to make a machine that we can hold a conversation with just as we hold a conversation with a person.

ANTHROPOMORPHIC INTELLIGENCE

For the first time in human history we will be able to talk with a hon-human species. That in itself of course is not a lot of use, but the machines that will have that ability will be of great use, and I foresee machines in the home that take the place of, or partly take the place of, the doctor, the lawyer, the general advisor. So we will have a machine we can talk to that will understand the family, that will give us medical advice, and will of course refer to human advisors where necessary, and generally will be an enormous benefit in the home. And not many years beyond that we will be able to produce machines which take over the role of teacher, so that we will have a single tutor for every student.

Looking a bit further ahead still, one can foresee the truly anthropomorphic robot with human intelligence, and in due course super human intelligence. A wonderful benefit that I foresee there is that we will then be able to give the sort of support and comfort, indeed even perhaps friendship, to the elderly and infirm who will represent an ever increasing proportion of our population.

So, I hope I have given you some feeling of the benefits that could accrue from this wonderful technology that is really only just round the corner.

BRITAIN'S POSITION

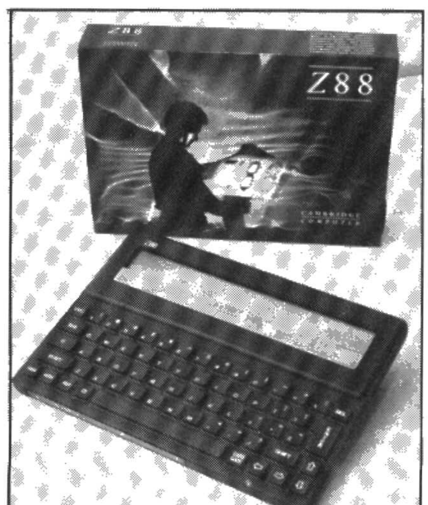
What I would like to say, though, is that we ought to look at the position that the United Kingdom has in this field. On the one hand we have a very strong position in the underlying technology. There is a great deal of pioneering work, as many of you of course know, and many of you have contributed to it, in the field of parallel processing or processing itself. We have even in this country designed some of the finest processors in the world, and there are not many countries that can say that.

Sadly, though we don't have the same position in producing the underlying silicon. Each of these machines might in the future take say a square metre of silicon which is equivalent to a hundred weight of the stuff and if we only need a couple of million of these machines a year, the same numbers say as we produce of cars today, that would require 10s of wafer fabrication lines and we in this country today do not have a single world standard wafer fab line. Not one. Korea has several, Japan dozens and America of course has a great many too. We do not have one. I think that is a great shame and a very serious matter.

SHADES OF SILICON

Greece fell to Rome, and when it did Archimedes was working in the sand and he turned round and a Roman was standing beside him and he said "Please, you are blocking the sunlight from me", and the Roman slew him.

Well ladies and gentlemen, unless we can become masters of silicon we too will stand in the shade. PE



The Z88 — an intelligent computing solution

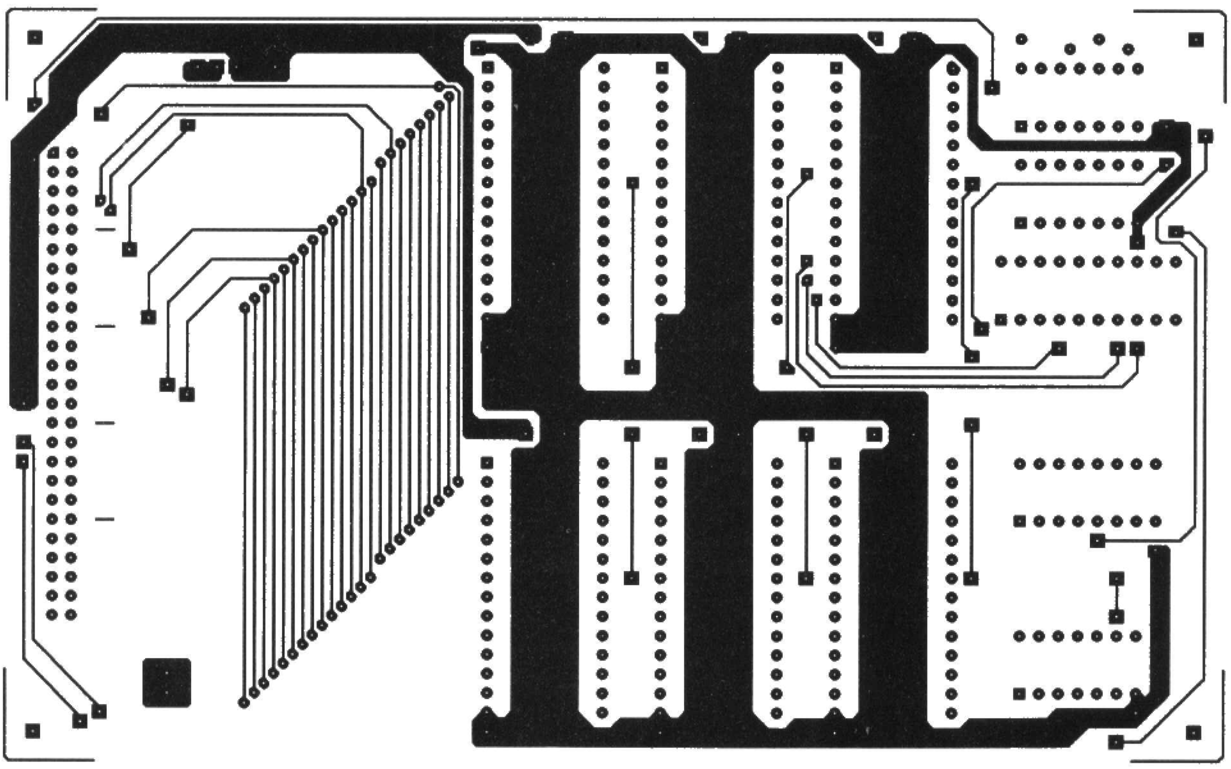
HOW TO USE PCB TRACK PATTERNS

FIRST MAKE TRANSPARENT COPY

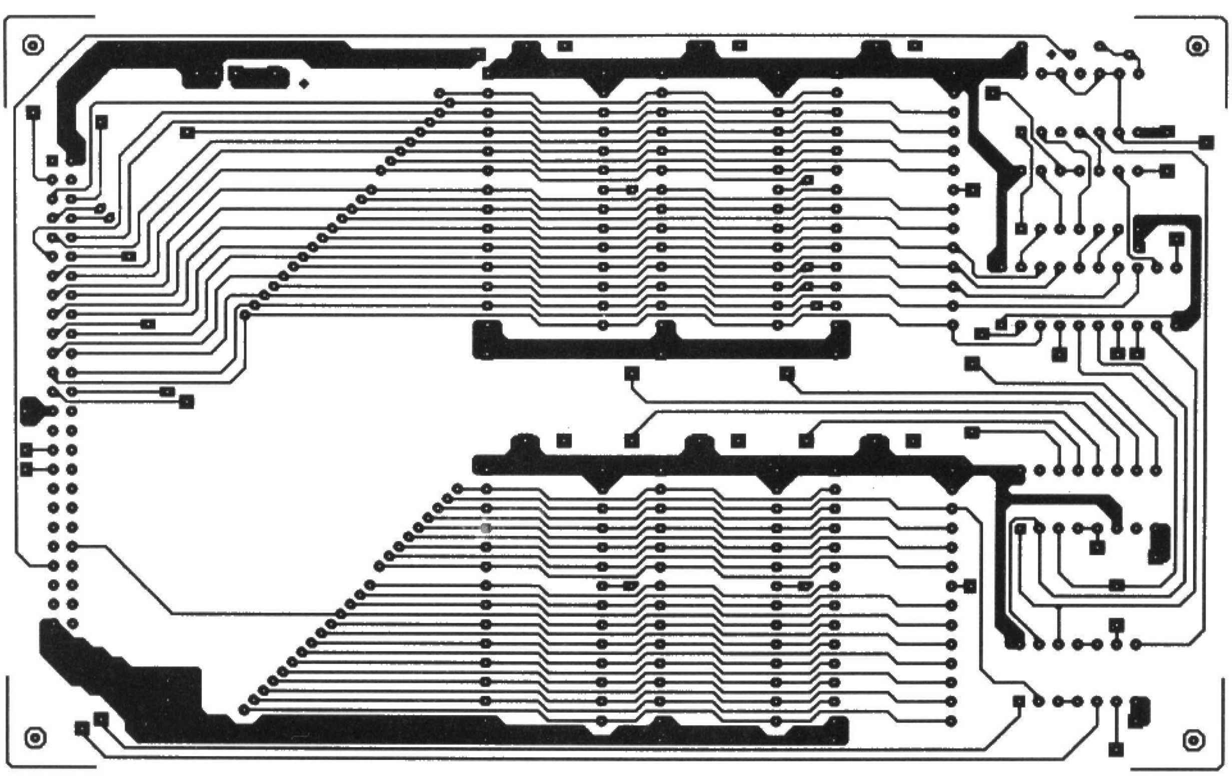
(We regret that we cannot supply transparent copies of PCB tracks.)

ISODRAFT METHOD

Have a normal photocopy made, ensuring good dense black image. Spray ISOdraft Transparentiser onto copy in



PE 173 *(Double Sided Board). Above, Component Side. Below, Main Tracking Side.*



accordance with supplied instructions. **ISOdraft** is available from **Cannon & Wrin,** 68 High Street, Chislehurst, Kent. Tel: 01-467 0935.

NEXT PRINT ONTO PCB

Place positive transparency onto photosensitised copper clad fibre glass, cover with glass to ensure full contact. Expose to Ultraviolet light for several minutes (experiment to find correct time – depends on UV intensity).

DEVELOP AND ETCH

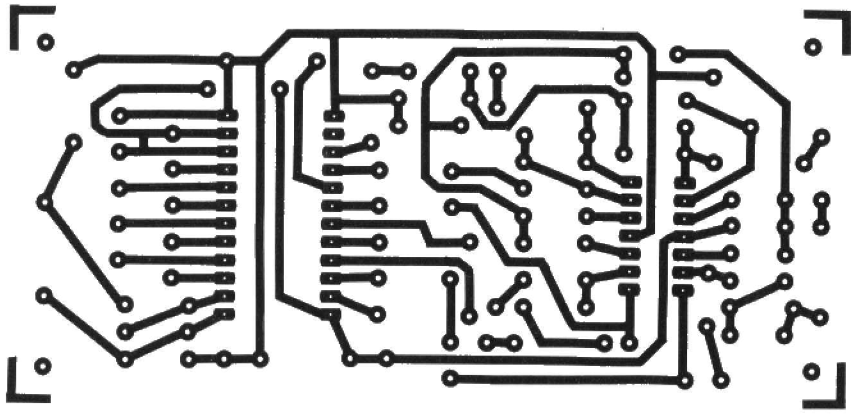
Develop PCB in Sodium Hydroxide (available from chemists) until clean track image is seen, wash in warm running water. Etch in hot Ferric Chloride, frequently withdrawing PCB to allow exposure to air. Wash PCB in running water, dry, and drill holes, normally using a 1mm drill bit.

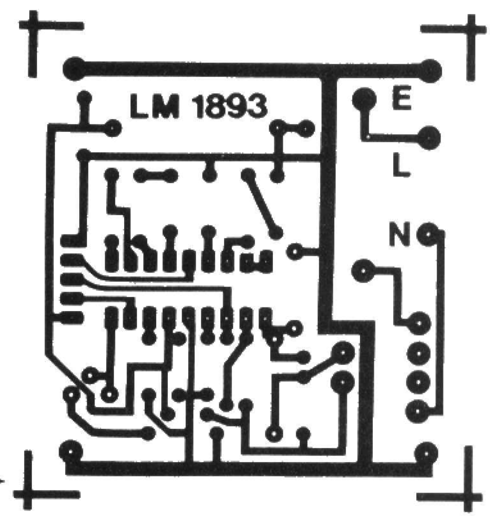
(PCB materials and chemicals are available from several sources – study advertisements.)

*** CAUTION – ENSURE THAT UV LIGHT DOES NOT SHINE INTO YOUR EYES. PROTECT HANDS WITH RUBBER GLOVES WHEN USING CHEMICALS.**

ALTERNATIVE METHOD

Buy your PCB ready made through the PE PCB SERVICE, most are usually available. PE





Voice Scrambler PCB ↑ (This print is smaller than lifesize). PE174 →

MAINS MODEM

BY MIKE MEAKIN

WALLS HAVE EARS

Transmission of signals through domestic type mains wiring is well established. The modules here, based on the LM1893 ic, can be used for half duplex operation with home micros, or simplex control with remote control ics.

This article will describe the operation and construction of a mains modem that will both impress and recover digital data upon the mains. The modem is in the form of a module suitable for interfacing to any digital controller.

The mains wiring system has been used for the transmission of control signals for over fifty years. The advent of microprocessors harnessed to control software enables "smart" systems such as energy management, office data communication, alarm and domestic controllers to be easily implemented with no additional costs for the wiring installation. The usual method of transmission is to modulate a high frequency carrier and impress the signal upon the mains. A receiver then demodulates the carrier to recover the original signal. Both amplitude (am) and frequency modulation (fm) are used and the proliferation of "wireless intercoms" demonstrate the ease of transmitting analogue signals.

Transferring digital data requires more elaborate circuitry. Amplifiers, voltage controlled oscillators, phase locked loops and discrete transistor output stages are required and they not only consume large areas of board space but need careful setting up to obtain optimum performance. This combination of analogue and digital control circuitry is well suited to fabrication on an integrated circuit and National Semiconductor manufacture the LM1893 which is the first monolithic device to contain all the active circuitry required for this function.

ALLOCATED FREQUENCY

Frequency shift keying (fsk) is the method of modulation used in the LM1893. The carrier is deviated between two discrete frequencies controlled by a logic level input. The benefits are similar to those obtained by using fm rather than am for radio reception and the method is well suited to the noisy conditions encountered in a mains wiring system. Carrier frequencies of up to 1MHz provide reasonable propagation and attenuation characteristics for both industrial and domestic wiring installations. However the requirements of non-interference with radio transmissions have led to the allocation of various bands for mains signalling with each band being used for specific purposes. The band available to the domestic user and specified for non-continuous or burst mode of operation is from 125kHz to 140kHz. The performance of the module conforms to the requirements of the Draft Standard for Mains Signalling

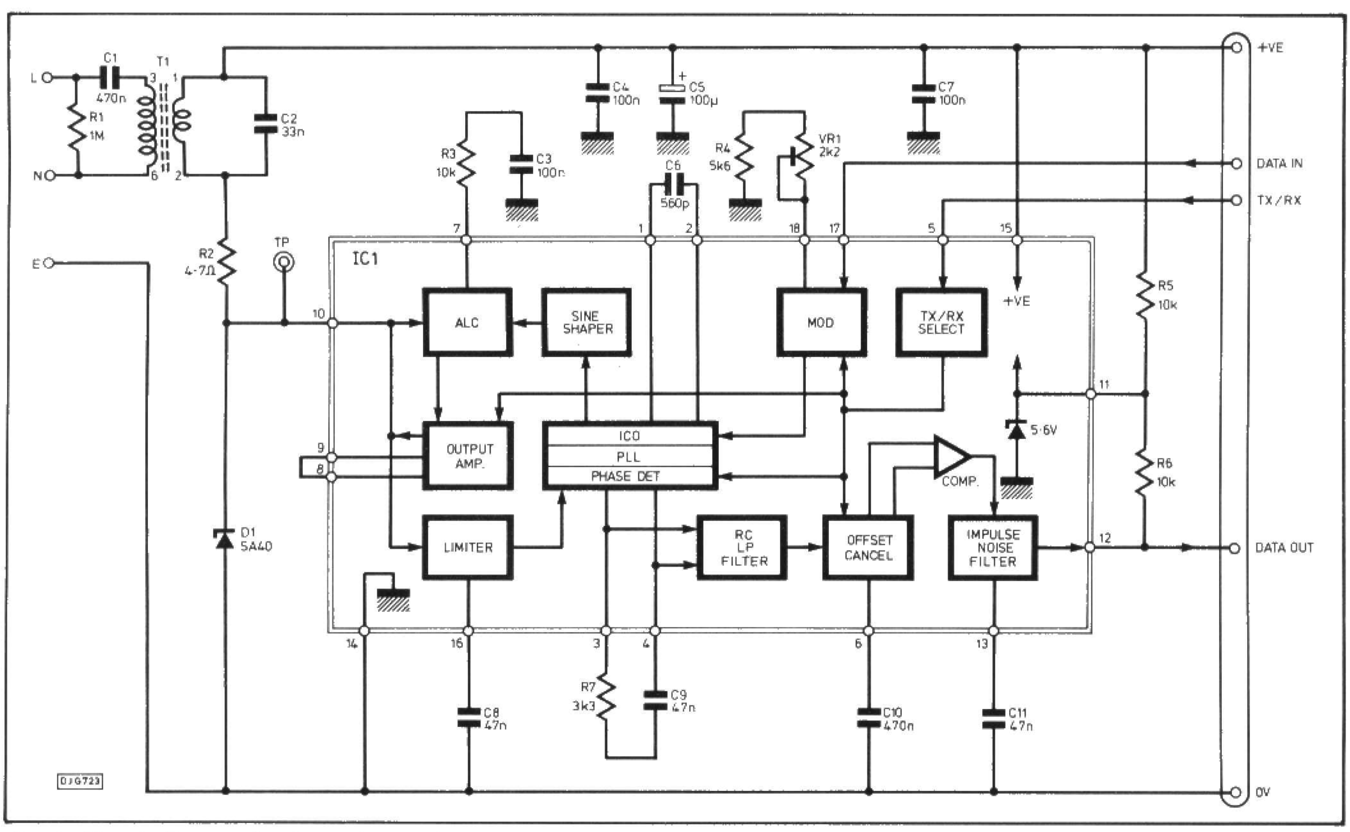


Fig. 1. *Circuit diagram for the mains modem.*

proposed by the British Standards Institution. No licence is required for operation.

The device is designed for half-duplex operation (transmit and receive, but not simultaneously) with the mode being selected by the logic level on the tx/rx control input. Digital data, at up to 4800 baud, can be applied to the data input and will shift the carrier by typically ±2.5% of the centre frequency. A second module set in receive mode, up to 500 metres distant and on the same phase will demodulate the carrier and present a logic level signal at the receive output.

CODING

Consideration must be given to a method of encoding and decoding the digital data as high levels of impulsive noise on the line will almost certainly corrupt long data streams. It is thus necessary to incorporate error checking and correction codes within the transmitted packets of data. Serial data from a standard uart is thus not suitable for direct transmission, however, it will function if occasional errors can be tolerated.

A typical system would comprise a microcomputer acting as a master controller communicating with a number of slaves. To utilise the half duplex capabilities of the modules would require a microcontroller at each slave so that they could recognise their unique address and respond to commands from the master. A virtually unlimited number of slaves would then both drive loads and return the status of various inputs to the master controller. Such a system is suited to energy management schemes where for example temperatures of individual rooms within a building could be monitored and the heating controlled as necessary to maintain remotely adjustable temperatures throughout the day and night.

The modules are easily interfaced to home micros and, with suitable software, a low cost local area network can be constructed. This would allow the transfer of data and files between micros and the shared use of common facilities such as printers.

REMOTE CONTROL

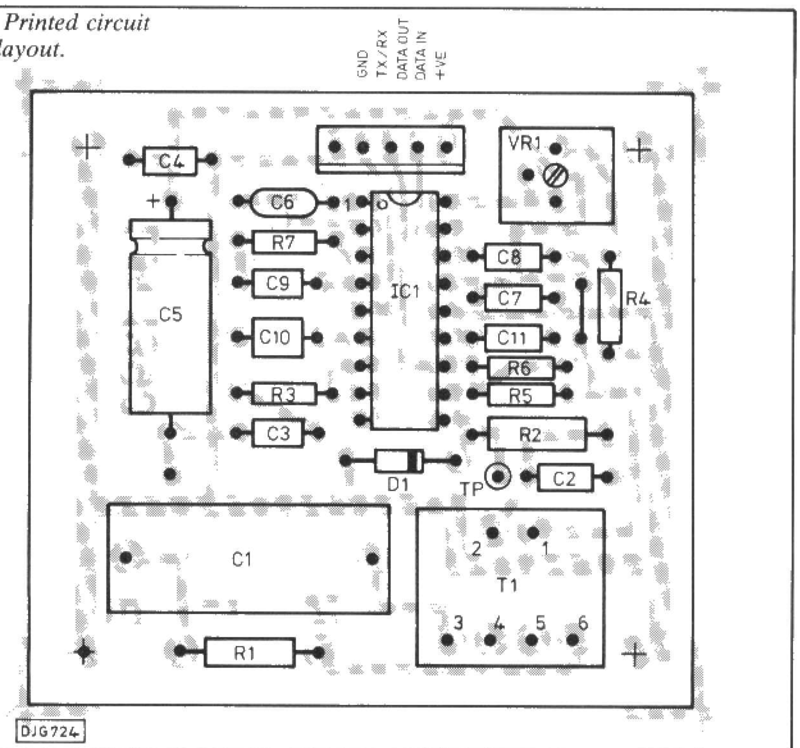
It is not always necessary to use a micro with the modules and for simple on/off control, remote control ics can be interfaced to the modules. A simple device that can provide up to 4096 codes for on/off control is the MM53200 encoder/decoder, again from National Semiconductor. The device was originally designed for remote controlled garage door openers but neatly interfaces to LM1893. Twelve switch inputs are encoded into a serial pulse width modulated data format that is transmitted via the modules. The received data is compared with the code set on the slave switch inputs. When four valid streams have been received the decoder output goes low. This simplex (one way) system could be used to activate loads (eg lights, alarms, etc). With the addition of a passive infra-red detector this could form the basis of a flexible burglar alarm system that can be easily transferred from room to room.

CONSTRUCTION

The full circuit diagram is shown in Fig.1, and the printed circuit board layout is in Fig.2.

WARNING: Mains voltage are lethal. The secondary of the coupling transformer is connected via a coupling capacitor to the mains. Therefore extreme care should be taken when testing or probing the module whenever it is connected to the mains. The module MUST be connected to mains earth and a fuse provided in series with the live lead. (See Fig.3.)

Fig. 2. *Printed circuit board layout.*



The usual precaution of observing the polarity of the electrolytic capacitor, diode and orientation of the ic will reward the constructor with a module that should work first time and at minimum cost. The board layout allows either a vertical or horizontal mounting pre-set to be used. A Veropin can be used for the test point and don't forget the small wire link. The power supply and inputs/outputs have been brought out to a 5-way 0.1 inch pitch Molex connector although wires can be soldered directly if required. Mains connections are purposely designed to be made to the pads on the underside of the board. A cover of unclad board or other insulating material should be attached to the track side of the completed board. This will minimise the possibility of contact with mains voltage. The board can be used as a "piggy-back" onto a mother board with connections being made with Molex pins or a flexible jumper strip. When soldering is complete the board may be scrubbed with a bristle brush and pcb solvent to remove the excess flux. This will allow the board to be inspected for good joints and no solder splashes!

TESTING

Two modules are required for a useful system. When both are complete DO NOT be tempted to connect them to the mains .... yet! Testing and tuning can be carried out using a dummy load/attenuator connected between the two modules as in Fig.4. Initially the current consumption of each module should be checked. When powered from a dc supply of 18 to 24 volts it should be in the order of 10mA in receive mode and 50mA in transmit mode.

The modules need to be tuned so that the current controlled oscillators are in-band and within capture range of each other. The coupling transformers then need to be trimmed to the centre of the two fsk frequencies. An oscilloscope and frequency counter will be required for accurate alignment.

Connect the oscilloscope and frequency counter between the test point (TP) and 0V. For each module in turn, tie the tx/rx control input and the data input high, eg to the positive supply rail. The module will then be transmitting on the low side of the centre frequency and a clean sine wave of about 20V p-p should be observed. Adjust the pre-set to bring the transmit frequency in-band (about 130kHz). Take the data input low

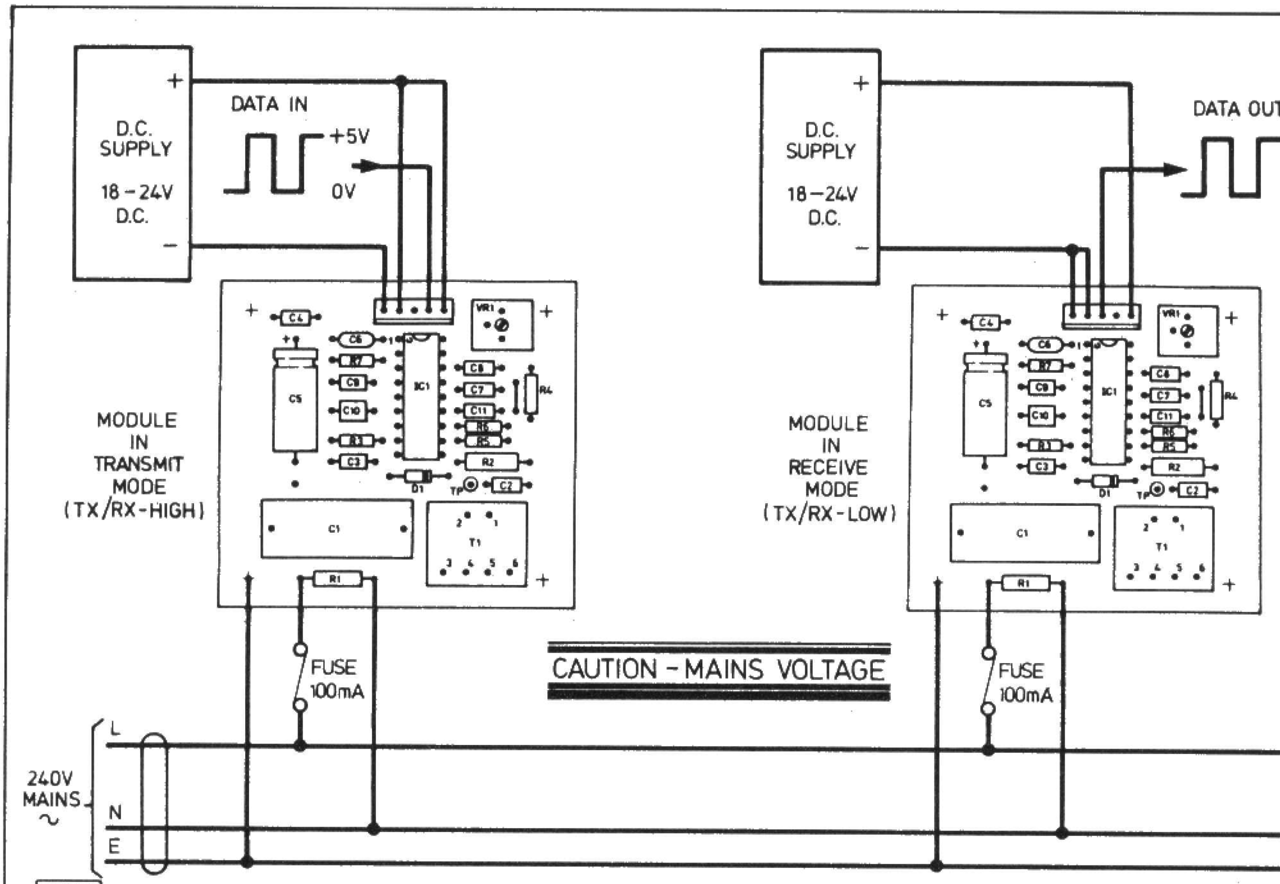
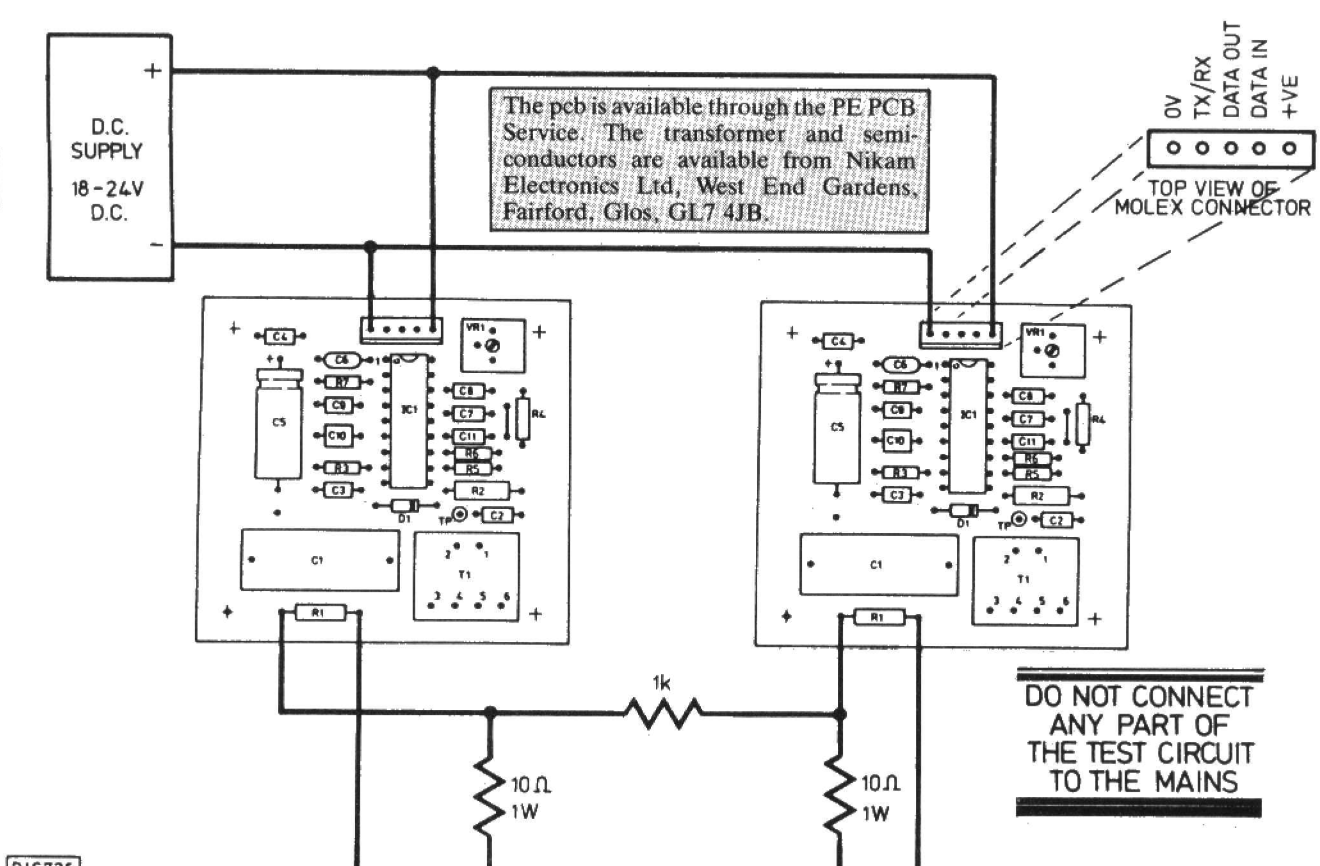


Fig. 3. *Connection of mains modem modules.*



The pcb is available through the PE PCB Service. The transformer and semiconductors are available from Nikam Electronics Ltd, West End Gardens, Fairford, Glos, GL7 4JB.

Fig. 4. *Mains modem tone-up test circuit.*

COMPONENT LIST

RESISTORS

R1	1M ½W carbon film
R2	4R7 ½W solid carbon
R3,R5,R6	10k ¼W metal film (3 off)
R4	5k6 ¼W metal film
R7	3k3 ¼W metal film

POTENTIOMETER

VR1	2k2 vertical or horizontal mounting preset

CAPACITORS

C1	470nF 50V ac X-class
C2	33nF polycarbonate
C3	100nF polycarbonate
C4,C7	100nF polycarbonate or ceramic (2 off)
C5	100μF 25V electrolytic
C6	560pF polystyrene 5%
C8,C10,C11	47nF polycarbonate (3 off)
C10	470nF polycarbonate

SEMICONDUCTORS

IC1	LM1893N National Semiconductor
D1	SA40A General Semiconductor

TRANSFORMER

T1	ZKB 490/228 80W Vacuumschmelze

MISCELLANEOUS

Printed circuit board, 18 pin-socket, 5-way Molex connector, Veropin, case and wire to suit.

(0V) and check that the frequency increases. Make a note of the two frequencies. The actual shift in frequency is determined internally and there is no adjustment. Remove the frequency counter and transfer the oscilloscope to monitor across the 10Ω load resistor on the secondary. The output amplitude should be about 3V p-p. Toggle the data input successively high and low either manually or by applying a 0 to 5V 1kHz square wave to the data input. Adjust the core of the transformer for equal amplitude at both the transmitted frequencies. The second module should then be tuned in a similar manner and adjusted for the best match in frequencies. This completes the alignment.

Finally, the transmission of data to and from each module should be checked. The modules may then be connected to the mains for use in the constructor's application.

OPERATION

In transmit mode a triangle wave generated by a current controlled oscillator is sine shaped and drives an internal transistor output amplifier. The centre frequency is set by an external resistor and capacitor and is shifted by ±2.5% depending on the state of the digital data input. The output amplitude is monitored by an automatic level control which maintains a distortion free sine wave output and compensates for varying loads. This output is coupled to a tuned transformer which isolates the circuitry from mains voltages, matches impedances and provides bandpass filtering. The secondary is capacitively coupled to the live and neutral pair. For safety a commercially available coupling transformer is recommended as it can provide the necessary isolation and breakdown voltage required. Of equal importance is the coupling capacitor which MUST be rated for 250Vac operation (X class). A 1M resistor bleeds away any residual charge on this capacitor when the modules are un-plugged. Very high energy pulses can be generated by other equipment connected to the mains (brush motors, scr controllers). Although the ic is internally protected, an external high speed semiconductor transient suppressor is used to clamp voltage spikes to a safe level. Zener diodes are not suited to this purpose as they are generally not fast enough.

When the tx/rx input is taken low the transmit circuitry is disabled and the controlled current is used as part of a phase locked loop demodulator (pll). Millivolt signals filtered by the tuned transformer are amplified, limited and drive the phase detector section of the pll. An external loop filter in conjunction with an internal low pass filter recover the raw demodulated signal. This is squared by a comparator whose threshold is automatically set to the centre of the signal swing. Spikes are effectively filtered by an impulse noise filter that produces 'clean' digital signals. The open-collector output is pulled up via a resistor to an internal zener regulated supply of 5.6V. PE

ZOLA POWER

NORTH OF WATFORD

Dear Sir,

I write regarding Zola McMalcolm's article on Bio-Chromatic Electronics in PE April 88.

I was dismayed that a serious Science Magazine could publish an article so behind the times until I realised that the research had been carried out South of Watford — clearly a case of the North/South divide, and it is well known that many Southerners are behind the *Times* (take a look in any City bound commuter train).

You see, up here we have known about the Electric Foxglove (*Digitalis Signalis Dichrocus*) for 20 years, although it is only recently that it has been fully understood.

The peculiar behaviour of the plant was first noticed by BR engineers working on the electric line near Crewe in the late 60s. They discovered that some plants growing close to the 25kV overhead cables showed a marked change in colour not evident on non-electrified lines, and that this colour change was less marked the further from the track the plants grew.

However, it was not until the hot summer of 76 that the tristate nature of the flowers was discovered when workers wearing sunglasses noticed that plants by the down-line had a different shading to those by the up-line. On closer examination it was found that the pigmentation cells had aligned themselves in the direction of the current (ie, to or from London). Hence, when seen through polarised sunglasses, the apparent difference in colour.

Engineers from Doncaster have now noticed the same effect on the East Coast electrification scheme, showing that there is little likelihood of the dichroism being localised. In fact one engineer claimed that the colour change was affected by the passage of trains and that on examining a plant he could say when the last train had passed and on which line.

He even went so far as to try growing plants in between the tracks, but this only proved that foxgloves were not hardy enough to withstand the buffeting from trains so close to them (not many living things can withstand the British Rail Buffet).

There are some other Northern inventions employing the electrical characteristics of plants of which I feel you may need reminding:

The toroidal R.T. Choke hybridised from the globe form by a GPO engineer in Wallsend is one. Another is the automatic current limiting in power supplies using various sizes of current leeks, first used in switch gear at Ferrybridge power station.

So come on PE, check on the authenticity of your news!

J.R. Watkinson, Sheffield.

Zola thanks you for further confirmation of the vegetative trend in some areas of British technological education.

She appreciates that the North is often the guardian of our times and suggests that BR at Crewe might examine the potential for hybridising Digitalis Signalis and Digitalis Electronicus to provide low cost intelligent control of rural crossing gates, especially in the vicinity of the renowned Sheffield cuttings. **Ed.**

APRIL AT F8

Dear John,

Well done PE.

That has got to be the best April Fool joke I've read in years. I am of course referring to the Investigative Feature in your April 88 edition called "Bio-chromatic Electronics".

I have to admit you had me fooled for half the article, until the section headed "Fortnight at F8". Then, when I read, "... the growth stopped vertically at the 128th cell ...", I was convinced.

It was not until the end of the article that I noticed the rather odd plant names of Digitalis Multiflora and Surillious Preposterosa. I was fooled by the detail of the article, the good diagrams, and also because there IS research being done on bio-electronics.

Once again, well done!

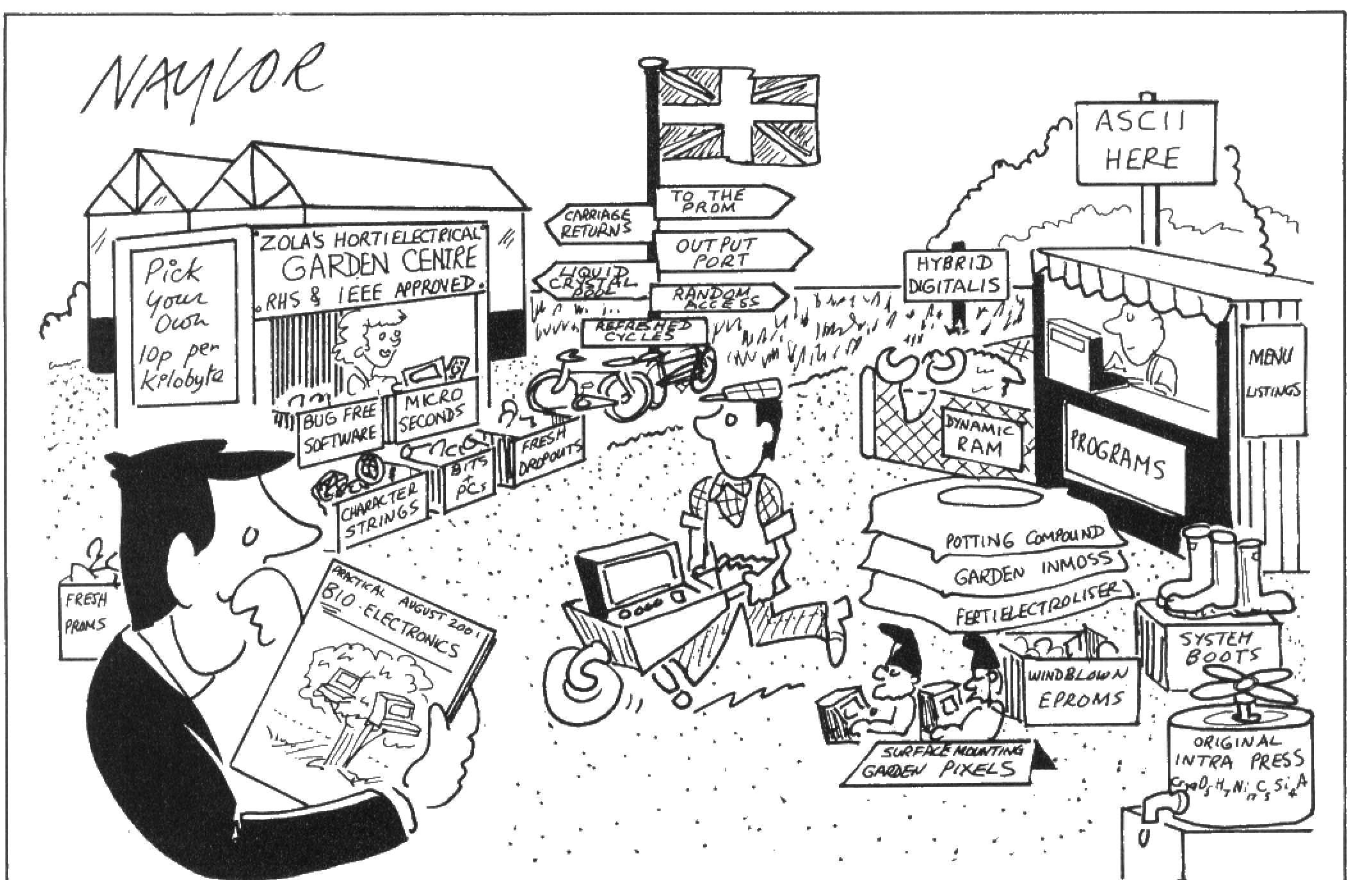
M. Oates, Manchester

Quite so, and Rekceb-Rotide Labs are still opening the mail!

DALI-ESQUE

Dear Rekceb-Rotide Labs,

Forgive me if I'm wrong and that the article in PE April is a cunningly disguised joke in which case I apologise for troubling you, but I would like more information on your bio-chromatics.



However, I bet a penny to a pound that the article is an excellent April Fool's joke. I find it hard to accept that the cells of a plant, found to react to tropisms, are found to have the name (out of all the millions of species of plant) of Digitalis. This Latin name sounds suspiciously like "digital". Digitalis is a plant name, but I still find it one helluva coincidence.

And when it's crossed with a plant called Surillious Preposterosa (sounds like silly-preposterous) and it has an ASA value of 100 (taken from photographic terminology where ASA is the light response factor of a film emulsion) then my notion of a joke takes form.

Upon turning to the cover I see I'm reading the April edition. If it's not a joke, my sincere apologies, but I feel that it is and thank you for a most interesting read.

K.K., Northants.

Digitalis is the true Latin name for the foxglove plant, of which there are about 30 species. The common English variety is Purpurea, but others, including Ambigua, Grandiflora and Lutea, occur across Europe and into North Africa.

Dali is admired by Zola and the "surreal" nature of some of his paintings inspired her in the selection of Surillious as a probable hybrid research candidate, even though the idea seemed preposterous.

Ed.

OBLIQUE HISTORY

A classical medical text written two hundred years ago by William Withering, "An Account of the Foxglove and some of its Medical Uses", commented upon the effect of an extract from foxgloves upon "the motions of the heart". The Digitalis extract still cannot be synthesised and the drug continues to be prepared from the foxglove.

Ed.

JOKE SPACE?

Dear Ed,

PE should have a comic strip on robots, or a serialised space travel fiction with electronic applications, remote controls and bionic capabilities. This would be good for lighter moods.

Bola Osibo, Nigeria.

I too am an SF fan — how many more of you feel the same way?

Incidentally, I recall one SF story of many years ago in which a well known author wrote about a submarine and its electronic communication abilities, setting the scene well into the future. I wonder if he is embarrassed by saying in the story that all the equipment used valves, since transistors had not proved to be practical alternatives! If I remember correctly, the story was "The Dragon in the Sea", by Frank Herbert. (Apologies, FH, if my memory is wrong!).

Ed.

AD SPACE

Dear Ed,

Sorry to criticise, but there are too many advertisements in PE and a few are getting rather expensive.

But don't ever leave out Dr Patrick Moore and Spacewatch – we must keep up with the stars!

N.R. Davidson, South Shields

You seem not to have read my Editorial of May 87 in which I commented on how much the financial success of a magazine is based on three main factors – publishers, readers, and advertisers. Readers want to read interesting articles and buy goods associated with them. Advertisers need to sell their products. We, the magazine, need you both for our revenue. These are somewhat simplistic statements but they represent a vital triangle of relationships. There are of course other relationships that are just as important, such as the authors, the typesetters, the printers, the newsagents and the distributors – but that's another story.

Yes, Patrick does write one of our 'star' columns, but all our authors have their own star qualities!

Ed.

TO BEEB OR NOT TO BEEB

Dear Ed,

Many of the computer projects you publish are for use with the BBC computer. Don't forget that some of us have other machines. I, for example, have a UK101 that I built myself many years ago and I would not get rid of it as I can still say "I built it".

Also, how about some more circuits for the Hobby Bus system, and a circuit for an eprom programmer that can be run from the RS232 of any computer? A general logic analyser for a scope but without a Beeb on the end of it would be useful.

P.J. Fasoli, Manchester.

Points taken. When we commission specific articles we normally select subjects that will have the widest appeal and inevitably computers like the Beeb find dominance as they are so popular. Recently we have also had circuits for Amstrads, Pets, C64s and Spectrums (or is the plural 'Spectra' or 'Spectrii?!). When it comes to non-commissioned articles, that is, those sent in by readers, we would be pleased to accept circuits that may relate to some of the less widely used machines as long as the articles are adequately written. The "Ingenuity Unlimited" section periodically included is an ideal place for such offerings. But for this sort of circuit we are in the hands of you, the readers. Prove to me that other computers deserve coverage by offering me circuits for them.

Since taking over as Editor in Jan 87 I have had very little correspondence relating to the Hobby Bus of 1986 and I can only assume that no-one was really interested in it. If I am wrong, tell me.

Ed.

READERS' LETTERS

RESPONSIBILITY

Dear Sir,

Our emergence as a technological society is comparatively recent. We have terrific powers today, powers that no other civilisation has ever known. People should ponder on the implications and tread lightly through the minefield.

A.J. Blake, Eastleigh.

Space prevents our publishing the full text of Mr Blake's letter in which he gave numerous examples of technological progress through the centuries.

As a magazine with an international readership of all ages we are deeply aware of our social and moral responsibilities. My outlook is that technology in general, and electronics in particular, is beneficial to society, and that although some aspects may bring hardships (changes in employment patterns for example), the overall advantages outweigh any disadvantages.

Ed.

PRIZEWORTHY

Dear Ed,

I must congratulate Barry Fox for his UKTechnology award. He has certainly earned it with his regular feature Leading Edge, which I find excellent, keeping me up to date with all the latest happenings in the electronics and communications field.

I also like the current features on semiconductors and satellites, and Industry Notebook.

Please run more competitions, with prizes like scopes, multimeters, etc.

M. Richardson, Alston.

DOGGERELL

Dear John,

Although I am not an animal hater, I am fed up with dogs and cats digging holes and planting unsavouries in and on my garden. Is there an electronic device around that will repel animals intent on such behaviour?

Desperate John Mumford, Roselands, Australia.

I'd heard that diggers are not unknown in Australia, though I thought a certain four-X lager usually cured down-under problems!

In the news pages of Dec 87 there was a report about a company marketing all sorts of products for repelling animals, from moles to pigeons. So I had a (somewhat humorous) chat with them at PAL Electronic Systems Ltd. The summary of call was that, yes, dogs and cats can be forcibly inhibited by electronic devices, but the action could be construed as cruelty by the RSPCA and other animal protection organisations.

Consequently PAL do not market this type of deterrent, nor is it right in these circumstances for me to advise on how it can be done. I can only conclude by saying that —

Though contented dogs are
much preferred
I hate it when they've gone
and erred
Leaving nasties across my
lawn interred.
These canine digs have much
occurred
And to professionals I've
referred.
But even if it seems absurd
Electronics daren't keep pets
deterred.

Sorry Desperate John. **Ed.**

BREAKING THE CODES

BY ROBERT PENFOLD

COMPONENT NUMBERS SOMETIMES ADD UP

The serial numbers which designate many components are a source of endless mystery and confusion, and not only to those who are new to electronics. But many of them contain useful information, which PE sets out to unlock ...

PUBLISHERS of electronic constructional projects tend to receive substantial numbers of enquiries about sources for particular components. (*How true! Ed.*) Often the components in question are specialised devices which are perhaps only available from a single source, but sometimes they are ubiquitous types which feature in virtually every electronic components catalogue. Letters of this type do not necessarily reflect a lack of initiative on the part of the writer; it can simply be that there is some confusion about the type number of component concerned. Some components are available under several different type numbers, and what might be specified as a "CA1458C" in a components list could be available as a "LM1458C" in one catalogue, and just a plain "1458C" in another.

Looking through a few component catalogues could give the impression that semiconductor part numbers are largely random in nature, with little logic or meaning behind them. This is not really the case though, and most type numbers give some basic information about components, such as the manufacturer, or the type of device (diode, transistor, etc.). The codes used in semiconductor numbering systems are not purely of academic importance, and an understanding of them can often solve problems when trying to select the correct parts from component catalogues.

PRO ELECTRON

Meaningful methods of component numbering predate the semiconductor era, and were in existence in the days when valves such as the EL41 reigned supreme. There were apparently some agreements between manufacturers about systems of valve numbering, but things seem to have been on a relatively informal basis. Although there has been some movement towards universal standards since those days, we still have a situation where several numbering standards are in operation, and some components do not conform to any of them. The main European body for standardised semiconductors type numbers is called "Pro Electron", which was set up in 1966.

Table 1

Letter	Material
A	Germanium
B	Silicon
C	Gallium Arsenide
D	Compound Material

The Pro Electron numbers are perhaps the most helpful, as they indicate the material used in the construction of each device (germanium, silicon, etc.), and also give the general type of the device (transistor, opto-isolator, etc.). In common with other methods of coding, the Pro Electron system does not provide any detailed information about components, and it does not even indicate anything as basic as whether a transistor is an npn or a pnp type. Most of the transistors that are popular in the UK have Pro Electron type numbers, including standard devices such as the BC109 and BC179. This system is also used for a large number of less common semiconductors, including devices such as the CNY17 opto-isolator and the BT109 thyristor, which few people probably realise are within this system.

Table 2

Letter	Function
A	Small Signal Diode (detection etc.)
B	Variable Capacitance Diode ("Varicap")
C	Low Power, Low Frequency Transistor
D	Low Frequency Power Transistor
E	Tunnel Diode
F	Low Power, High Frequency Transistor
G	Oscillator Diode
H	Magnetic Sensitive Diode
K	Hall Effect Sensor (In open magnetic circuit)
L	High Frequency Power Transistor
M	Hall Effect Sensor (In closed magnetic circuit)
N	Opto-Isolator
P	Photo Sensitive Diode
Q	Light Emitting Diode (led)
R	Low Power Thyristor
S	Low Power Switching Transistor
T	High Power Thyristor
U	High Power Switching Transistor
X	Multiplier Diode (Step recovery, etc.)
Z	Zener Diode (Also Transient Suppressor, etc.)

LETTER TABLE

The first letter indicates the material used in the construction of the component, and there are only four possibilities here (see Table 1). The second letter indicates the function of the component, as detailed in Table 2. These letters are followed by a three or four letter suffix number, which seems to have no meaning. However, each new device has a number one higher than its predecessor, and so this number does indicate whether or not a device has been recently registered or is a relatively old type. The numbers seem to start at 100 rather than 000.

Components with a type number having this format are primarily intended for use in consumer electronic equipment. Some devices have the slightly modified format where a third letter and a two or three digit number are used (e.g. BFY51). The additional letter is usually "X", "Y", or "Z". The exact letter used seems to be of little or no significance, but this general type of component numbering indicates that devices are intended for use in industrial equipment.

The system is slightly different for reference voltage diodes, which includes zener diodes. These have the three letters plus two or three digit codes, but with additional letters/numbers to indicate the nominal reference voltage and tolerance. The first letter indicates the tolerance and range of available values, as detailed in Table 3. The following digits give the nominal reference voltage with the letter "V" showing the position of the decimal point. As an example, a BZY88C8V2

Table 3	
Letter	**Tolerance/Value Range**
A	1%/E96
B	2%/E48
C	5%/E24
D	10%/E12
E	20%/E6

has a voltage tolerance letter of "C", which equals 5%, and this range of devices are available in E24 series of values. The voltage is 8V2, or 8.2 volts in other words.

GROUPIES

Some transistors are given a suffix letter or numbers to indicate the gain group. In the world of amateur electronics this only seems to manifest itself in the form of an "A", "B", or "C" added to devices such as the BC107, BC177, and their many derivatives. "A" is the lowest gain group and "C" is the highest. These groups represent gains of 110 to 220, 200 to 450, and 420 to 800 (at 2 milliamps). Note that it is always alright to use a device having a gain suffix letter where a device without such a letter has been specified, but a substitution in the opposite direction may not be satisfactory.

JEDEC

Most semiconductors which do not come under the Pro Electron system have Jedec type numbers. Jedec apparently stands for "Joint Electronic Device Engineering Councils", and it is an American organisation. Devices which come under this system have the familiar 1N*** and 2N*** type numbers.

This system of component "tagging" does not give a great deal of information about the devices. In fact the only substantial piece of information it provides is the number of leadout wires each component has. This is one greater than the first digit in the type number. In practice this gives some indication as to the type of semiconductor, as shown in Table 4, but it does not give very specific information.

Table 4	
Prefix	**Device Type**
1N	Diode or Diac
2N	Transistor (Including fet and ujt types), Thyristor, or Triac
3N	Dual Gate MOSFET
4N	Opto-Isolator
5N	Opto-Isolator

A letter "N" always follows the first digit, and this is followed by a two to four digit serial number. As with the Pro Electron system, this number gives a rough indication as to how modern or old each component happens to be.

Gain grouping seems to be relatively rare with Jedec type numbers, and I have only encountered it with the 2N2926 transistor which was very popular about ten years ago. A coloured spot on the body of this component indicated its gain group, as detailed in Table 5. In components catalogues a suffix letter is used to indicate the gain group (eg "2N2926G" for a "green" gain group type), but the coloured spot and not this letter is marked on the component itself.

A few Jedec type numbers include an "A" suffix, as in 2N706A and 2N2369A. This shows that the device is an improved version of the original component which lacks the suffix.

Table 5	
Colour	**Gain Group (at 2 milliamps)**
Brown	35 to 70
Red	55 to 100
Orange	90 to 180
Yellow	150 to 300
Green	235 to 470

JIS

Although Japanese transistors seem to be used a great deal in many parts of the world, they only play a very minor role in amateur electronics in the UK. Most of the Japanese semiconductors that are available are specialised types such as power mosfets. Japanese semiconductors have JIS (Japanese Industrial Standard) type numbers, and probably most readers will have come across some of these.

The first digit indicates the number of leadout wires in the same way as the Jedec coding, but JIS numbers are only used for devices with two to four leads. This number is followed by a two letter code which indicates the general type of the component, but the first letter always seems to be an "S", and it is really the second letter that provides the information. The type numbers actually marked on components frequently have the first two digits missing. As the "S" is superfluous anyway, and the number of leadout wires present should be obvious from an inspection of the component, this should not lead to any confusion! Table 6 gives a list of letters and the device types that they represent.

A two to four digit serial number follows the first three digits, and there is sometimes a single letter suffix. This indicates that the device concerned has been approved by a particular organization.

To take an example JIS part number, the 2SK49 is a three lead device as it has "2" as the first digit. The "SK" code indicates that it is an N channel fet. In fact it is a power mosfet, but the JIS codes do not provide very specific information, and all three lead N channel fets have "2SK" as the first three digits.

Table 6	
Letters	**Device Type**
SA	pnp Transistor (High Frequency)
SB	pnp Transistor or Darlington (Low Frequency)
SC	npn Transistor (High Frequency)
SD	npn Transistor or Darlington (Low Frequency)
SE	Diode
SF	Thyristor
SG	Gunn Diode
SH	Unijunction Transistor
SJ	N Channel fet
SK	P Channel fet
SM	Triac
SQ	Light Emitting Diode (led)
SR	Rectifier
SS	Small Signal Diode
ST	Avalanche Diode
SV	Variable Capacitance Diode ("Varicap")
SZ	Zener Diode

NON-STANDARD

A lot of transistors do not have type numbers which conform to any of the three standards described above. Many are produced with only some basic form of identification, as required by the purchaser of the batch (usually an oem). These components often find their way into amateur hands in the form of surplus devices sold off in bargain packs of untested devices. Some real bargains are to be had here as the transistors are often fully serviceable, full specification components. The snag is that there is not usually any way of determining exactly what you have bought — you will only know that the devices are of some general type.

Many manufacturers market devices under their own type numbers, and these sometimes give some basic details about the devices. A list of well known prefixes and the corresponding manufacturers is provided in Table 7, which also indicates any further information that these type numbers impart.

Table 7	
Prefix	**Manufacturer etc.**
MJ	Motorola Metal Cased Power Transistor
MJE	Motorola Plastic Cased Power Transistor
MPS	Motorola Small Signal Plastic Cased Transistor
MRF	Motorola Radio Frequency Transistor
RCA	RCA Devices
RCS	RCS Devices
TIP	Texas Instruments Plastic Cased Power Transistor
TIS	Texas Instruments Small Signal Plastic Cased Transistor
ZTX	Ferranti Devices

Table 8

Prefix	Manufacturer
AD	Analogue Devices
AM	Advanced Micro Devices
CA,CD	RCA
CEM	Curtis Electromusic Specialties
KB	Toko
LM,LF,LH,MF	National Semiconductors
HA,HI	Harris Semiconductors
HA,MN	Hitachi
ICL,ICM	Intersil
IR	International Rectifier
MC	Motorola
OP,REF	Precision Monolithics
ML	Microsystems International
MK	Mostek
NE,SE,SA	Signetics
SG	Silicon General
SL,SP	Plessey
SN,TL	Texas Instruments
uA	Fairchild
ULN	Sprague
XR	Exar
Z	Zilog
ZN	Ferranti

INTEGRATED CIRCUITS

So far we have ignored integrated circuits, but these do not come under the Pro Electron, Jedec, or JIS standards. Some integrated circuits are only manufactured by a single company, but equipment manufacturers are not keen on being tied to a single source of supply. Most types are therefore produced under license by at least one other company, or "second sourcing" as this is termed. Integrated circuits that are produced by more than one manufacturer may be given a single type number, but usually different manufacturers will use slightly different names.

In most cases the middle part of the name is a series of numbers, and this is common to all components of a given type, regardless of the manufacturer. It is the letters ahead of the type number proper that vary from one manufacturer to another, and these letters therefore indicate the origins of components. Table 8 lists some of the more common prefixes and shows the manufacturers to which they correspond.

Integrated circuit type numbers do not generally provide any information about the electronic characteristics of the components, but a suffix letter or letters often indicate the type of package used. The integrated circuits on sale to amateur users are almost invariably of the plastic cased dual-in-line variety, which usually have a "P" or an "N" suffix. RCA seem to use an "E" suffix instead, as in CA3140E. Many integrated circuits are also produced in more expensive (and presumably more durable) ceramic packages. These mostly have a "D", "J", or "L" suffix. Metal canned integrated circuits seem to be quite rare these days, but devices of this type generally have an "H", "G", "T", or "S" suffix.

It should be apparent from this that a popular integrated circuit will be available under a number of different type numbers, as it will have several manufacturers (and prefixes), and will have several types of encapsulation (and hence suffixes). In components catalogues the suffixes are often omitted since only the standard plastic dil versions are offered. Sometimes the manufacturer's prefix is also omitted, but many retailers now seem to offer popular devices in several versions. The 1458C dual operational amplifier integrated circuit for instance, is offered by some retailers under this basic type number, but others offer it as a CA1458C (RCA), LM1458C (National Semiconductors), and a MC1458C (Motorola).

LOGIC NUMBERS

Logic integrated circuits have more or less the same range of suffixes and prefixes as linear types, but these are rarely mentioned in catalogues. ttl types are just listed under their basic 7400 series type numbers, while cmos devices are just given their 4000 series of numbers. Ttl integrated circuits now have the added complication of letters added to the middle of the type number (a "midfix"?). These indicate that the components are from a family of improved devices, such as the "LS" used to indicate low power Schottky devices (eg "74LS02").

Table 9 gives the "midfixes" for a number of ttl logic families. This subject of logic device types was covered in some detail in an article in the September 1986 issue of PE incidentally, and readers who require more information on this topic should refer to this earlier article.

Table 9

Letters	TTL Family
None	Standard TTL
AC	Advanced CMOS
ACT	Advanced CMOS (TTL input/output levels)
ALS	Advanced Low Power Schottky
C	CMOS
F	Fast Advanced Schottky
H	High-Speed
HC	High-Speed CMOS
HCT	High-Speed CMOS (TTL input/output levels)
L	Low Power
LS	Low Power Schottky
S	Schottky

CMOS SUFFIX

Cmos devices have suffix letters that are unique to this particular range of components. The first letter is an "A" or a "B", but the "A" series are now obsolete. These original "A" suffix components suffered from problems with ineffective static protection circuits at their inputs, and outputs which often had a maximum drive current that depended on the number of inputs that were driven. The "B" series components have improved static protection circuits at their inputs, and buffer stages at their outputs which give consistent drive currents. These changes inevitably produced differences in the electrical characteristics of the two series. These are mostly quite minor, and are unlikely to be of importance when cmos is used in the conventional manner.

Unfortunately, there are no end of circuits around which utilise cmos integrated circuits in what are really linear or pseudo-linear applications rather than true logic circuits. They are often used as simple amplifiers and oscillators for example. In general, in these non-standard circuits the old "A" series work better than the "B" types, and in particular, the older type provided much wider bandwidths. Consequently, some old circuits published in the days when there were only "A" series devices will not work with "B" type components. There can also be problems with instability if a circuit assumes that a "B" type device will be used, but a wider bandwidth "A" series component is used in its place. There can also be problems with circuits that utilise the fets of a cmos device as individual components, which is common practice with the 4007 inverter and complementary pair. Any buffer components could then seriously impede the operation of the circuit. When cmos devices are operated in linear type circuits it is difficult to predict exactly what will happen if the wrong version is used.

As far as I am aware, no "A" series cmos devices are currently manufactured. Those that are available from sources of surplus components often seem to cost more than the current devices! Some cmos components are available in "UB" versions, which are unbuffered devices. These are not just the old "A" versions under a different name, as although they do not have the buffer amplifiers, they do have the improved static protection circuits. A "UBE" device is more likely to work properly as a substitute for an "A" series type than is an ordinary "B" type device.

Cmos logic devices normally have a second suffix letter to indicate the package style. This is "D" for ceramic dil, "E" for plastic dil, and "K" for flatpack packages. The plastic dil types are the only ones normally sold by hobby market suppliers. PE

SPACEWATCH

BY DR PATRICK MOORE

OUR REGULAR LOOK AT ASTRONOMY

A new source of water on the moon has been suggested. Geminga may prove to be a neutron star, despite the lack of radio waves reaching us from it.

Now that the Americans have publicly announced their intention of going back to the Moon in the foreseeable future, attention is starting to swing back to it; for some years after the end of the Apollo missions it was shamefully neglected – even by some amateur astronomers. Obviously, we are anxious to know just what conditions future astronauts will meet; remember that so far we have positive information from only half a dozen sites. It is generally believed that there is a total lack of hydrated material (the old idea of extracting water from the lunar rocks has been abandoned) but now an intriguing suggestion by Dr. Albert Metzger, of JPL, has raised the possibility of ice, kept frozen by being confined to regions where no sunlight ever penetrates – that is to say, the floors of some deep craters in the polar zones. Metzger suggests that the water could have been dumped on the Moon by impacting comets, or even expelled from the Moon's interior. If the ice is bombarded by cosmic rays, gamma-rays could be produced, and it may therefore be worth searching for traces of gamma-radiation from the next orbiting lunar satellite.

Meanwhile, everyone is waiting for news of the physical condition of Yuri Pomanenki, who spent over ten months on the space-station Mir. If he shows no major ill-effects, the way to Mars should be open.

The Sky This Month

The main planetary interest this month is on the two innermost members of the Sun's family, Mercury and Venus, both of which are evening objects. They are, of course, quite unlike each other, and the only outward similarity is that both show phases from new to full, similar to those of the Moon.

Mercury, only just over 3000 miles in diameter – and therefore more comparable with the Moon than with the Earth – is a mere 36,000,000 miles from the Sun on average. Its maximum angular elongation from the Sun is never as much as 30 degrees; this May it attains 22 degrees (on the 19th), but it is well north of the celestial equator, so that this is the best chance this year for seeing it with the naked eye. It should be easy enough; you can of course sweep for it with binoculars (though not until the Sun is fully set). At the end of the second week in May, Mercury will actually be brighter than any star apart from Sirius, though it is always seen against a brightish background. Telescopically, you will see it as a three-quarter shape, becoming half about May 15 and then a narrowing crescent. Surface markings are almost impossible to make out; all our knowledge of the Mercurian craters and mountains has been drawn from one probe, Mariner 10, which made three active passes in 1973 and 1974.

Venus, of course, is brighter than any other planet or star. During May it will show up as a crescent, and this is the best time for trying to observe the Ashen Light, about which I wrote last month. Mars is visible in the morning sky, and the apparent diameter reaches 10 seconds of arc by the end of May, so that planetary observers will already have started serious work. Jupiter is out of view, but Saturn is a morning object in Sagittarius; the rings are wide open, and a small telescope will show them, but the planet is well south of the celestial equator, so that from Britain it is inconveniently low down.

There are two full moons this month – on the 1st and the 31st; new moon falls on May 15. There are no lunar or solar eclipses. Of the meteor showers, the most interesting is that of the Eta Aquarids, which should be active until about May 20; the predicted maximum is May 5. The ZHR is estimated at about 35. (The ZHR is the number of naked-eye meteors which an observer would expect to see under ideal conditions, with the radiant at the zenith; in practice, these conditions are never met!) The Eta Aquarids are interesting because they are associated with Halley's Comet. Conditions are favourable this year, because near shower maximum the Moon will not interfere.

We have now lost not only Orion, but virtually all his retinue, though the Twins (Castor and Pollux) and Capella can still be seen; Capella never actually sets over Britain. The Great Bear, Ursa Major, is very high up, which means that the W of Cassiopeia is at its lowest in the north. Follow round the "curve" of the Bear's tail and you will reach the brilliant orange Arcturus; continuing the curve leads on to Spica in Virgo. Rather low in the south-west, look for the well-marked quadrilateral of stars marking Corvus, the Crow, which is easy to identify even though it is remarkably lacking in interesting objects!

The "Summer Triangle" (Vega in Lyra, Altair in Aquila, and Deneb in Cygnus) is now well on view by mid-evening. Later in the night, look low in the south for Antares, the red super-giant leader of the Scorpion. However, much of the southern aspect is filled by large, faint constellations such as Hercules, Ophiuchus (the Serpent-bearer) and Serpens.

One of the main spring constellations is Leo, the Lion, which lies south of Ursa Major, and is easy to find because of the 'Sickle', a curved line of stars of which Regulus is the brightest member. Not far from Regulus is a very red star, R Leonis, which is variable. At its best it may exceed magnitude 5; it is then visible with the naked eye, though binoculars are needed to bring out its colour. At minimum it drops to below magnitude 10. It is at maximum this month – on May 29 – and is worth seeking out. It is a typical 'Mira' pulsating star (named after Mira in Cetus, the brightest member of the class) and has a period of 312 days, though this may change slightly from one cycle to another.

GEMINGA TRACED?

One of the most baffling objects in the sky is 2CG 195+04, better known by its nickname of Geminga – a gamma-ray source in Gemini. It was detected in the early 1970s, and is one of the strongest sources, but up to now absolutely nothing has been seen in the position optically. Geminga has remained obstinately shy.

Astronomers have been puzzled. If Geminga were a pulsar, or neutron star, it might be expected to emit radio waves; but it does not. So can it be something entirely different?

Gamma-ray astronomy is a relatively new science, because it has to be carried out mainly from rocket or satellite-borne equipment, and the gamma-ray flux is always weak even from the most intense known sources (such as the Crab Nebula). Geminga could hold some important clues. In 1983 the Einstein X-ray observatory was launched, and the Italian team led by Giovanni Bignami decided to see whether any X-radiation could be found coming from the position where Geminga ought to be. They found it. When they were confident of the position, the next step was to look for a visible object. One star, of magnitude 21, was an early suspect, but had to be rejected when it was found to be an ordinary G-type star of the same type as the Sun.

Not to be daunted, Jules Halpern and David Tytler called in the Palomar 200-inch reflector, which is the largest in the world apart from the frankly unsatisfactory Russian 236-inch. The Palomar reflector was completed as long ago as 1948, but it is now much more effective than it was then, because it can be used with the latest electronic equipment – and as we all know, electronic aids are fast superseding photography. *(We have an article on this coming shortly. Ed).*

It was found that there were two stars close to the indicated position of Geminga. One was of magnitude 24.6 and the other 25.5, which is faint by any standards, and would be impossibly so but for electronic equipment. It was then found that the fainter star, G2, was unusually blue. This, plus its X-ray spectrum, indicates that it is an isolated neutron star, from 1500 to 3000 light-years away, and with a surface temperature of from 500,000 to 1,200,000 degrees Celcius. And if this is so, it is probably Geminga.

Why, then, do we not receive radio pulses? The reason is that a pulsar operates rather like a rotating search-light beam – the two beams of radio emission come out from opposite sides of the neutron star. And if we are not in the right position, the beams will not sweep over us, and we will receive no pulses.

This seems to be the case with Geminga. Of course, we cannot yet be sure; but all the evidence indicates that we have at last tracked down this strange, elusive object which has guarded its secrets so well. **PE**

Surrey Satellite

The University of Surrey's spacecraft engineering research unit is building a third UoSat-Oscar spacecraft, the UoSat-C. Nasa has agreed to provide a launch for it on a Delta launcher, scheduling it for late 1988, with a proposed circular orbit at 500km.

UoSat-C will carry engineering, science and communications experiments developed through collaboration between professional engineering and amateur radio communities. This and other satellites in the programme provide space science and engineering facilities readily available to amateurs and professionals. Since 1983 UoSat has played a major role in an international collaborative project developing cost-effective satellite communications techniques. Other experiments include radiation studies, attitude determination, control, stabilisation and rf modulation.

The satellite will be powered from GaAs solar cells, and will include patches of experimental GaAs, InPe and Si solar cells with a variety of newly developed cover-slides.

SEMICONDUCTORS

PART 7: MOSFET POWER AMPLIFIER PROJECT
BY ANDREW ARMSTRONG

DISCRETION IS THE BETTER PART OF HIFI

Mosfet power amplifiers are often claimed to sound better than bipolar designs. There is a good reason for this. Even though a mosfet design may give a similar distortion figure to a bipolar design, the type of distortion is less offensive to the ear. Build this project and find out for yourself.

This month, instead of sticking to theory or building block circuits, I have designed a mosfet power amplifier fit to grace any hifi system, and we will see how theory applies to the design of such a project. The power amplifier module here has a printed circuit layout, and a kit is available for those who wish to construct it. When operated on ±30V power supplies, it will deliver at least 60W rms into a 4 ohm load.

The project here is just a power amplifier without a preamplifier. It has many applications, including disco, guitar amplification, and hifi. For those who wish to use the module to make a hifi stereo amplifier, a suggested design of preamplifier is shown in Fig. 68, but no pcb layout is available, so this would have to be built on Veroboard or similar.

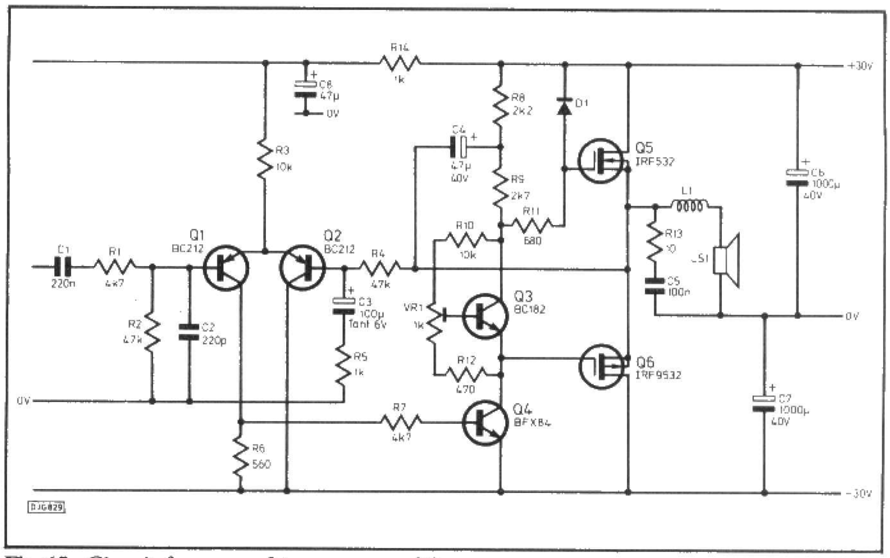


Fig.65. *Circuit for a mosfet power amplifier.*

CIRCUIT DESCRIPTION

The circuit diagram of the amplifier is shown in Fig.65. Split power supply rails are used, which allows the loudspeaker to be directly coupled to the output stage. This is generally an advantage because it removes the low frequency response limitation associated with output capacitors. It does mean, though, that the dc offset on the output of the amplifier must be low. This point is covered in detail later.

The output devices, Q5 and Q6, are a complementary pair operated in the source follower configuration. This makes for good symmetry which helps in achieving low distortion, and has two other advantages. Because the voltage gain of the output stage is less than unity, and the speed of response is higher than with output taken from the drain terminals, the likelihood of oscillation is much reduced. In addition, the absence of signal on the drain terminals means that there is no stray feedback via the heatsink's capacitance to the rest of the circuit, which again reduces the chance of oscillation as well as preventing frequency response degradation.

A beautifully symmetrical output stage is wasted unless the drive signal is also symmetrical. The driver stage is bootstrapped to make it run at an almost constant current. This means that asymmetry caused by variations in transistor gain with changes in collector current are eliminated.

C4 is the bootstrap capacitor, and it helps in the following manner. The time constant of C4 with R8 and R9 is much longer than that of typical output signals, so that, with respect to signals, the voltage across C4 is virtually constant. Because the output voltage is following the drive signal, with a small voltage loss, the voltage across R9 is almost constant. This means that the current hardly varies, and Q4 works more linearly than it otherwise would.

Bootstrapping gives another advantage as well: current to charge the gate capacitance of the mosfets is maintained even at the positive peaks of signal. In fact the charge on C4 maintains gate drive to above the power supply rail. If this were allowed, it would mean that the output voltage could approach the positive supply closer than it can approach the negative supply (because the drive signal cannot go more negative than the negative rail). To provide symmetrical clipping on overload, R11 and D1 are added.

BIAS

Transistor Q3, and resistors R10, R12, and VR1 set the gate source voltage for the output devices, to bias them to the conduction range. This provides an approximate temperature compensation, because although the resistance of fets has a positive temperature coefficient, the threshold voltage has a negative temperature coefficient. The negative temperature coefficient of the voltage across Q3 is approximately the same, so the quiescent current will not vary wildly with temperature.

The input stage of the amplifier uses a long tailed pair of pnp transistors; signal fed to the base of one, negative feedback to the other. Additional power supply hum rejection is provided by R14 and C8. The voltage across the tail resistor is approximately 26V, which is much greater than the signal voltages expected on the bases of Q1 and Q2, so the tail current may be regarded as approximately constant at 2.6mA. This is calculated to provide the correct voltage across R6 to bias Q4 on when the current is approximately evenly shared between Q1 and Q2.

OFFSET

The even sharing of current betweeen Q1 and Q2 is necessary to minimise the offset voltage between the two bases. It is also necessary to use transistors from the same gain selection band, and ideally transistors with matched gain. Generally, however, the choice of B grade transistors will guarantee a close enough match. It is also necessary for R2 and R4 to be of the same value. In this way, the dc path from 0V to the base of Q1 is the same as the dc path from the output of the amplifier to Q2.

Any leakage current in C3 will spoil this effect, so a bead tantalum type is chosen. Any net offset voltage, which may be negative or positive, will appear across C3. However bead tantalum capacitors can withstand small reverse voltages up to a maximum of 300mV without damage, and the offset should be under 50mV, so there should be no problem.

The ac gain of the amplifier is set by R4 and R5, and is (R4+R5)/R5. The lower the value of R4 and R2, the lower the input impedance of the amplifier, and the poorer the low frequency performance for any value of C1. With the values shown the frequency response will be about 3dB down at 15Hz.

The high frequency performance of the amplifier extends to at least 100kHz, at which frequency stray capacitance between input and output could cause oscillation. To prevent this, C1 is added to limit the frequency response of the input. However, the wide frequency response of the rest of the circuit minimises the possibility at high frequencies.

The lower the gain of the amplifier the lower the distortion as well, and if a lower gain than that shown is required it would be better to increase the value of R5 rather than reduce the value of R4 and R2. If a higher gain is needed, R4 and R2 may be increased. The circuit is suitable for gains in the range 20 to 100.

To reduce the likelihood of oscillation still further, R13 and C5 are included to provide a high frequency load for the amplifier at frequencies at which the inductance of most loudspeakers causes them to have a high impedance. The use of a small inductor consisting of a few turns of wire wound round a resistor in series with the output also contributes to stability.

LAYOUT AND HEATSINKING

For best stability and lowest distortion good grounding and good decoupling are essential. The pcb layout in Fig.66 is designed so that the ground track is a short thick track along one side of the board, to which two local power supply decoupl-ing capacitors are connected. These capacitors, C6 and C7, are not intended as the power supply reservoir

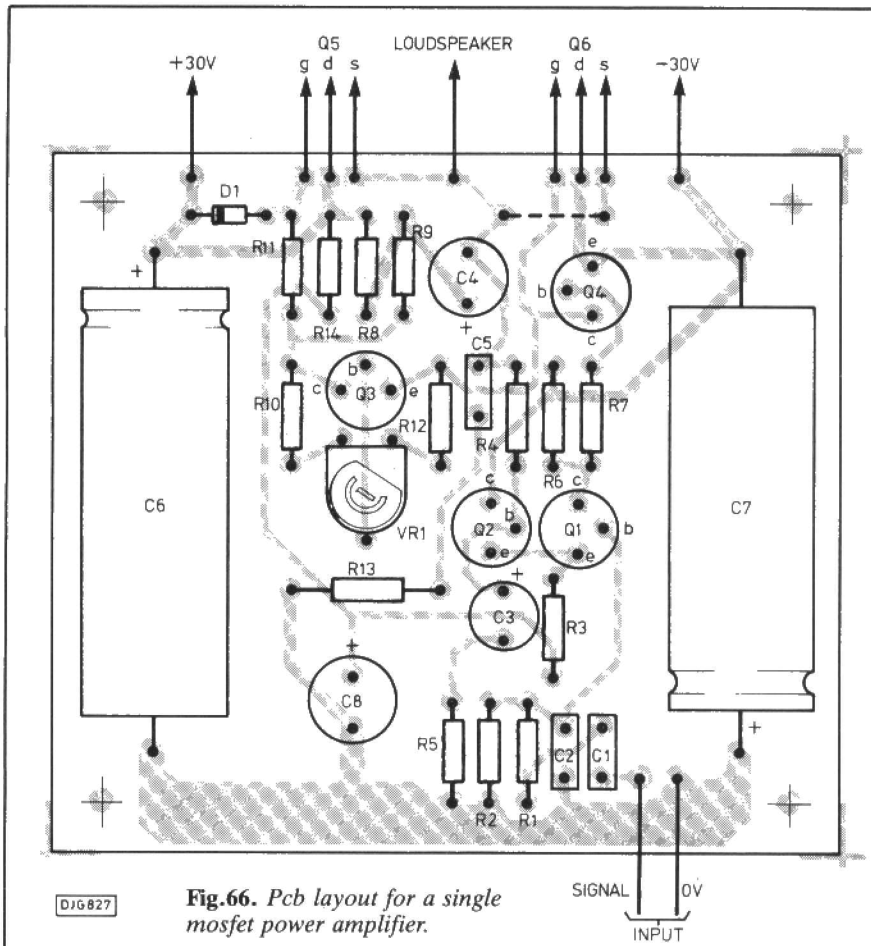


Fig.66. *Pcb layout for a single mosfet power amplifier.*

capacitors. They are merely intended to prevent signal from being imposed on the power supply due to heavy peak current demands flowing through the resistance of the wiring. The use of these capacitors also has the beneficial effect of minimising cross coupling between two modules in a stereo amplifier.

The power mosfets are both mounted at one edge, in such a way that they can be bolted to a heatsink. Because the tabs of the mosfets are connected to the drain terminals, insulating washers must be used to prevent electrical contact between mosfet and heatsink.

The heatsink must be chosen to keep the case temperature of the mosfets to below 110°C under all circumstances. Assuming that the amplifier module is used with 30V supplies and a 4 ohm load, the maximum total dissipation of the mosfets is 46W, that is to say 23W each. To cope with this case a heatsink with a thermal resistance of 1°C/W would be required. It would however be unrealistic to assume that this dissipation would be maintained for a protracted period under normal circumstances, so a somewhat smaller heatsink could be used with the very small risk of the amplifier overheating under exceptional circumstances. To make it overheat would require a sustained sinewave signal of approximately two-thirds maximum output.

The dissipation of the amplifier used with a typical music waveform would be much lower, so a heatsink of 2°C/W *may* be acceptable. If there is any serious doubt about the capability of the heatsink to dissipate the required power, a thermal switch may be added to cut off the power supply at a high temperature.

POWER SUPPLY

To achieve an output power of 60W into a 4 ohm load, a current of 3.9A rms (5.5A peak) is needed. The voltage developed across the load at this power is 15.5V rms, which corresponds with 22V peak. To provide a source current of 5.5A, an IRF532 requires a gate to source voltage of 5V, so the gate voltage must be able to reach 27V. The p channel hexfet needs slightly more gate to source voltage, so a negative gate drive of 28V is necessary.

All this suggests that a nominal power supply voltage of 30V will suffice, as long as it does not sag to less than 28V at maximum load. A 25V transformer with an adequate power rating would be a reasonable choice for the power supply. A suitable configuration is illustrated in Fig.66. The maximum output power can be increased by increasing the power supply voltage, but care must be taken not to exceed the voltage ratings of any of the components. With the components shown in Fig.67, the maximum permissible voltage would be 40V. The

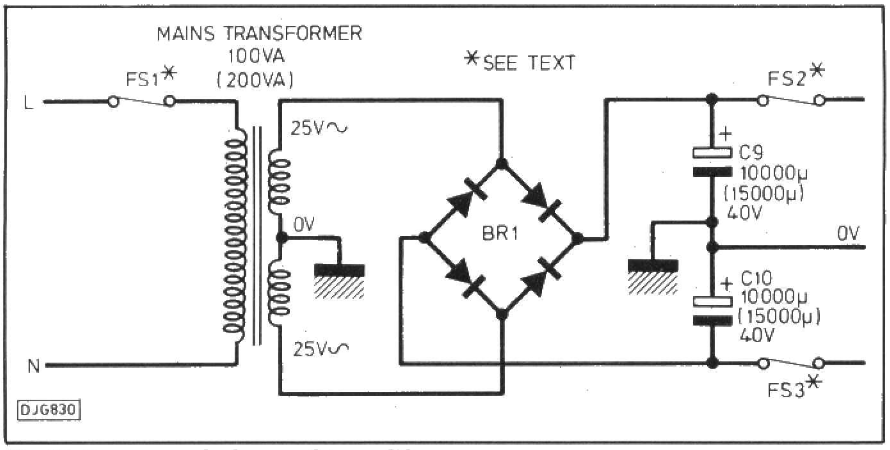


Fig.67. *Power supply for mosfet amplifier. Values in brackets are for a stereo amplifier.*

power supply must not exceed this voltage even with just the quiescent load of the amplifier, and with a mains voltage 5% above nominal.

CONSTRUCTION AND TESTING

Assembling the amplifier on the printed circuit board is straightforward. The important point is that the mosfets should be soldered in last of all, and should be protected from static by aluminium foil or conductive foam until required. They should be soldered in using an earthing soldering iron, and only after the constructor has touched an earthed object to discharge any static which may have built up.

The only component requiring any special thought is L1. This is intended to improve stability when driving a reactive load, and is not critical. To make this inductor, simply wind as many turns of 0.2 or 0.25mm wire as will fit on a single layer on a small value resistor, for example 10Ω. This inductor may be used to connect between the output of the pcb and the output socket of the amplifier.

If a dual bench power supply is available, the pcb should be tested before it is connected to its own power supply. It should be supplied from current limited supplies of 30V, and the power should be connected without a load or an input signal. The supply current should be measured, and VR1 should be set for a quiescent current of 50mA.

The output offset should then be measured with a voltmeter. The presence of over 100mV of offset indicates the need to check the construction. If after careful examination everything appears correct, the value of R2 may be changed to adjust the input offset, by trial and error. This is a last resort, and should not be necessary. It indicates a large difference in gain between Q1 and Q2.

DISTORTION

If an oscilloscope is available, the quiescent current may be adjusted more accurately. A load of the intended resistance, 4 ohms or 8 ohms, should be connected to the loudspeaker output, and the input should be connected to a sinewave signal at a frequency well above the audio range, approximately 100kHz would be suitable. Adjust the amplitude so that the output waveform is just not clipped, and then set the quiescent current so that the waveform is just not distorted. Please note that a loudspeaker may be unsuitable as a load, both because its inductance may reduce the loading, and because it may overheat and die due to this stringent test. A high power resistor is a much better bet.

This adjustment method is effective because the decreased loop gain at higher frequencies makes inherent non-linearity more visible on the waveform. Distortion occurs before the feedback can correct it, and is therefore visible on the output waveform. This demonstrates that the amplifier is inherently linear before the feedback is applied, or at least that it has no abrupt non-linearities.

This means that subtle but annoying types of distortion, such as transient intermodulation distortion, are minimised. The sound quality is audibly better than with other amplifier circuits offering nominally the same harmonic distortion level, but with inherent non-linearities disguised by negative feedback. In this latter case the distortion products are more obtrusive because they have a wider spectrum.

FINAL ASSEMBLY

Once the module has been checked and tested as far as possible, it should be assembled into its case. Special care should be taken to make good thermal contact between the output transistors and the heatsink. Because the tabs of the power fets are connected to the power supply rails, electrical isolation from the heatsink is needed. The best way to achieve these conflicting requirements is to use a Silpad insulating washer and the appropriate plastic bush on the mounting bolt. If Silpads are not available, then a smear of heat transfer compound on each side of a mica washer will ensure reasonable heat transfer.

To avoid unfortunate oscillation, hums and clicks etc, the wiring should be routed sensibly. The ac power supply wiring should be kept as far as possible from everything else, especially from the input wiring. The dc power supply wires should be fairly thick, and should be laced or clipped together. If two amplifiers are used in the same case, then the power supply connections (including 0V) should be connected back to the main reservoir capacitors separately. The 0V connection *between* the reservoir capacitors should be short and thick.

The input and output connections should be connected to 0V on the pcb, not at the power supply. The input connection should be made using screened lead, and should be kept as far as possible from the transformer. It should also have a decent clearance from the output connection.

If the output connection needs to be longer than the leads on L1, then it should be made with twisted wire to minimise radiation which may be picked up on the input. This isolation is important. The amplifier is stable with a wide variety of loads, but it has a wide bandwidth and will form an oscillator if feedback is applied external to the pcb. An amplifier of more modest bandwidth would not be vulnerable in this way, but would be less hifi.

When all has been assembled, double check that the power supply connections are the right way round, then carry out a final test to show that all connections are correct. You should now have an amplifier which works well and does not add its own interpretation to the original sound.

AMPLIFIER SPECIFICATIONS

Power output into 4Ω load with ± 30V supplies = 60W min, 90W typ.

Power output into 4Ω load with ± 35V supplies = 100W min.

Heatsink required for 60W continuous has thermal resistance of 1°C/W.

Distortion at voltage gain of 20, into 8Ω load is less than 0.1% at up to 80% of the maximum available power (set by power supply voltage).

ADDENDUM

As originally designed, this amplifier provides 60W, though this can be increased to 100W by using 35V power supplies. However, the need to keep the maximum power supply voltage below 40V peak under any conditions renders this option slightly dodgy.

For those who feel the need for the magic figure of 100W, a better bet is to use higher voltage rated components in some areas. This approach would make it possible to increase the power supply voltage still further and deliver 100W

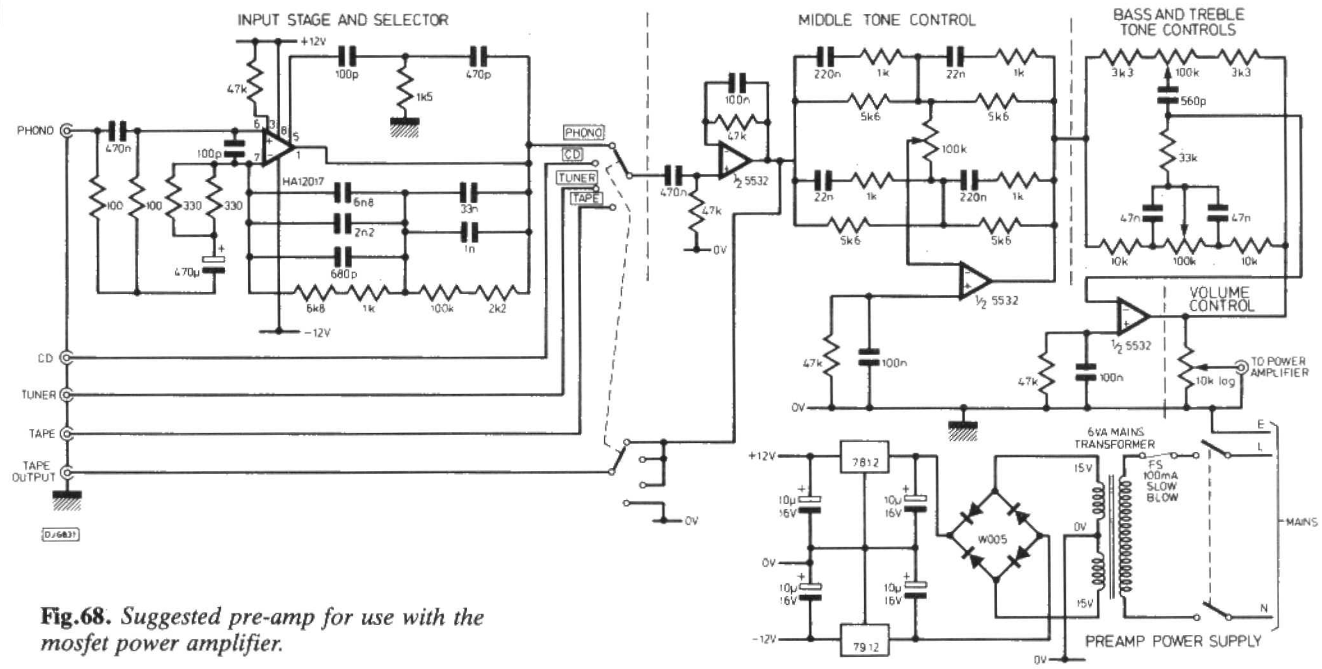


Fig.68. *Suggested pre-amp for use with the mosfet power amplifier.*

COMPONENTS

(Bracketed component types are for higher power version.)

RESISTORS

(2% ¼W metal film or metal oxide.)

R1,R2,R4	47k (3 off)
R3	10k
R5,R14	1k (2 off)
R6	560Ω
R7	4k7
R8,R9	2k7 (3k3) (2 off)
R10	10k (12k)
R11	680Ω
R12	470Ω
R13	10Ω

CAPACITORS

C1	220n polyester 0.2" pin spacing
C2	220p any dielectric 0.2" pin spacing
C3	100µ 6V tantalum bead
C4	47µ 40V (63V) radial electrolytic
C5	100n polyester 0.2" pin spacing
C6,C7	1000µ 40V (63V) axial electrolytic (2 off)
C8	47µ 40V (63V) radial electrolytic
C9,C10	10000µ to power one amplifier, 15000µ to power two. 40V(63V) high ripple electrolytic. (2 off)

CONSTRUCTOR'S NOTE:

The pcb and a kit of parts are available from Specialist Semiconductors Ltd. (Address in advert.)

SEMICONDUCTORS

D1	1N4148
Q1,Q2	BC214C (BC212B) **NOTE:** The BC214C will give slightly lower output offset. Apart from this, BC212B is suitable for either version.
Q3	BC182 or equivalent.
Q4	BFX84 (2N1893) or equivalent.
Q5	IRF532 (IRF632)
Q6	IRF9532 (IRF9632)
BR1	Any bridge rectifier rated at min 6A for one amplifier or 12A for two, minimum voltage rating 100V (120V). eg International Rectifier KBPC602 or GI KBPC802 for one amplifier, high power version, or Mullard BY260-200 for two amplifiers, high power version.

MISCELLANEOUS

Transformer:
One amplifier, 30-0-30V, 100VA standard power.
One amplifier, 40-0-40V, 150VA higher power.
For two amplifiers, double VA rating.

FS1	slow blow, 500mA per 50VA of transformer rating e.g. 150VA transformer needs 1.5A slow blow fuse.
FS2,FS3	5A slow blow. **NOTE:** Two pairs of fuses should be used for two amplifiers.

into 8Ω. The necessary changes are shown in brackets in the parts list.

In my view it it not likely to be worthwhile unless the amplifier is to be used with very inefficient loudspeakers or in an exceptionally large room. The audible difference on doubling the power output is not very great, and in practice most amplifiers will outperform their specification and deliver about 100W anyway.

ABOUT THE PREAMPLIFIER CIRCUIT

This preamplifier circuit is tested and works well, but no printed circuit board layout is available. It is divided into stages which may be included or left out at the preference of the individual constructor. The simplest possible configuration would simply include the input selector switch, the phono equaliser if required, and the volume control connected directly to the output of the selector switch. The first 5532 buffer could be included if the tape output was required.

Either or both of the tone control stages may be included, but if any active circuitry at all is included then the power supply is required. The power supply voltage of the power amplifier is so different from that needed by the preamplifier that there is no point in trying to power the preamplifier from it. The use of a separate power supply also removes the possibility of interaction between the two circuits, and allows the preamplifier to be built into a separate case if required. PE

AMSTRAD ROM EXPANSION

BY SIMON DEAN

96K OF ROM IN ONLY SIX BITS?

One answer to a shortage of memory space in a computer is to add sideways rom expansion. The system described here can handle up to 252 roms, but for the sake of practicality the design is based around a six-rom unit.

WHEN the Amstrad CPC range of computers were conceived, their designers built in tremendous capabilities. I refer in particular to the provision for adding expansion (sideways) roms to enhance the already powerful operating system. Adding these roms is much simpler and cheaper than most people imagine, and certainly within the abilities of most home constructors. The rom expansion board described here was built for around £14.00 excluding pcb and case and allows up to six external roms to be added.

EXPANSION ROM

An expansion rom is a 16K read only memory chip containing a program (or programs) which can be made to replace the on board Basic rom. It follows from this that all roms are mapped in the area of memory normally occupied by the Basic rom ie &C000-&FFFF. Up to 252 roms can theoretically be added to the system, and these can be split into two types:–

(a) Foreground roms – These usually contain one large program which replaces the Basic rom completely, such as, for example, another high level language like Pascal.

(b) Background roms – These provide additional commands to augment the existing operating system, rather like rsxs (resident system extensions). The disc operating system is one such rom.

Of the 252 possible roms, only seven (15 on 664 and 6128 machines) may be of the background type, the rest must be foreground. It is expected that most users will not require more than six expansion roms, background or otherwise, not least because these tend to be a little expensive, and for this reason and to keep the additional circuitry simple, only six sockets are provided on this board.

The main advantage of storing programs in rom is that none (or very little) of the ram of the computer is taken up by the program itself. This is very

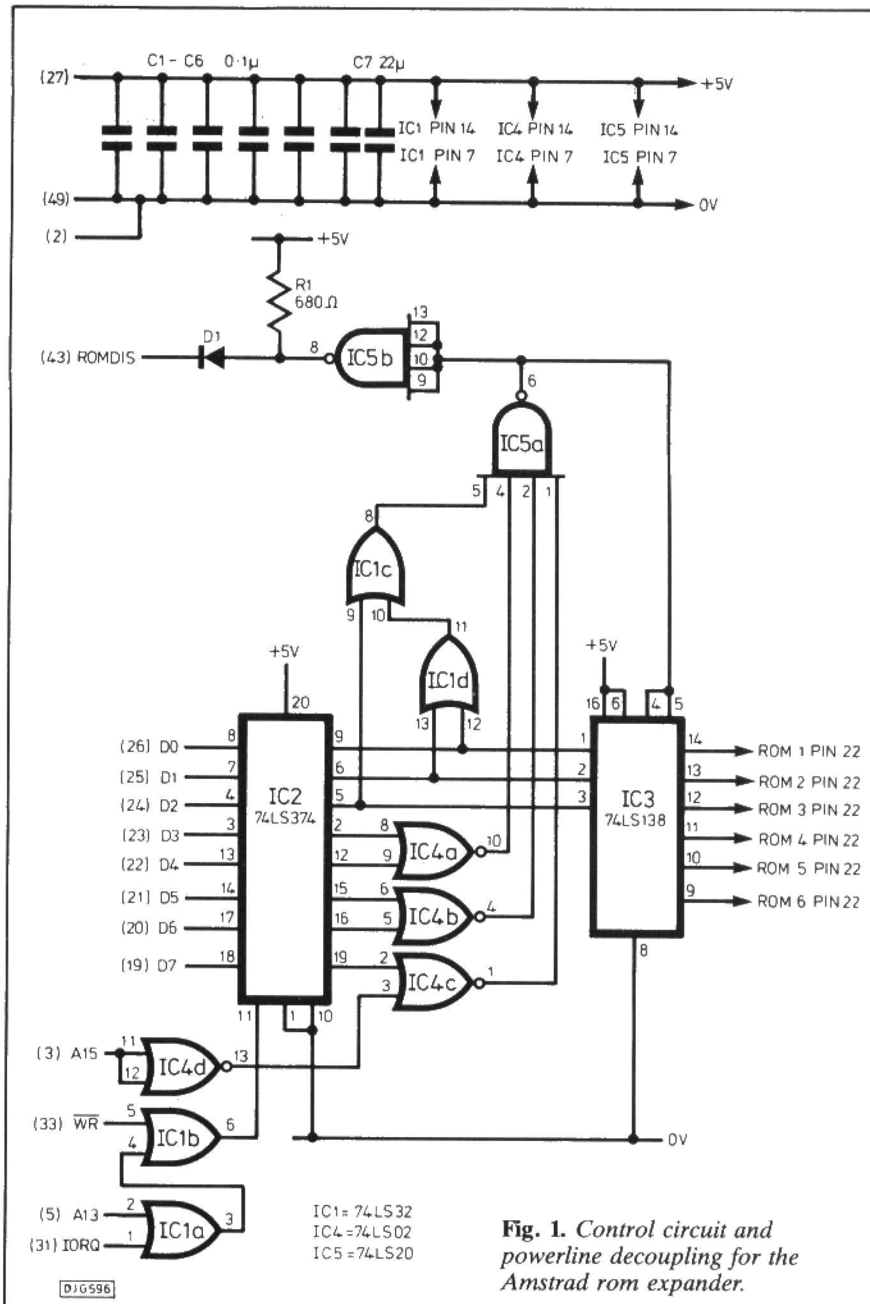


Fig. 1. *Control circuit and powerline decoupling for the Amstrad rom expander.*

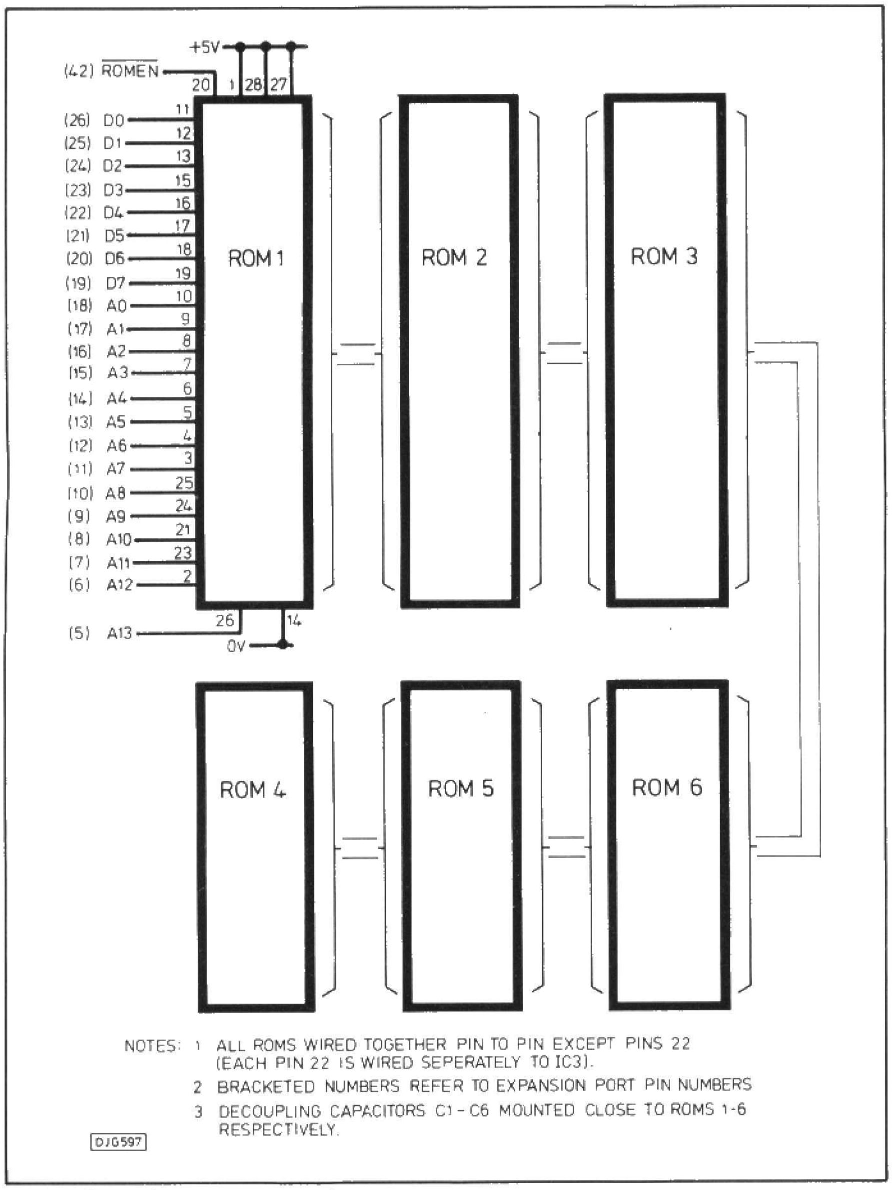


Fig. 2. *Extension roms connections.*

noticeable with word processing programs, which if ram based, allow only a small amount of the system's ram to be used to store the text. Rom based word processors (such as Protext – used to write this article!) allow almost all the computer's ram to be used to store text (typically 38K or more). Programs in rom are also instantly available, without having to wait while the program loads.

THE CIRCUIT

The computer chooses which rom is selected by writing the rom select address to I/O location &DF00. If a rom is fitted at that address, all further READ operations from the top 16K of memory will be from that rom. If no rom is present, then the on-board Basic rom is read.

As can be seen in Fig.1, the circuit is quite simple. IC1a and IC1b detect the presence of I/O address &DF00 on the bus, and latch the rom select address (present at the time on the data bus), into IC2. Note that because of the way that the Amstrad computers use the I/O space, it is only necessary to detect address line A13 going low to know that the address is &DF00, greatly simplifying the decoding process. Most hardware supported by the system is mapped in this way, each with a different address line in the low state.

If the rom select address is between one and seven inclusive, the output of IC5a goes low, enabling decoder IC3. The outputs from this decoder select the respective rom by pulling its OE (output enable) pin low. IC5b provides a high level on the ROMDIS pin to disable the internal rom. The circuit is so arranged to ensure that ROMDIS is asserted *before* the external rom is selected to avoid contention between internal and external roms as switching takes place.

Whenever the operating system is using the firmware (lower) rom, all other roms (including external roms) must be disabled. This is achieved simply by including address lines A15 in the external rom enable/disable circuitry on the expansion board. Whenever the lower rom is in use, A15 will be low, since the rom occupies address 0000–3FFFH, this low level disables external rom decoder IC3 via IC5a.

By now, some of you may have realised that the disc rom is normally rom seven, and that the computer will receive a response both from this rom and from our expansion board when a rom search takes place. This will not cause any problems in practice since the computer cannot actually tell that ROMDIS has been asserted by more than one device, but obviously a rom must not be fitted at this address.

CONSTRUCTION

The expansion box may be wired on a prototyping board, although in view of the large number of connections, and because wiring errors can prove fatal to the computer, the use of the double sided printed circuit board in Fig.2 is strongly recommended. The component layout is shown in Fig.3. Care should be taken to ensure that the transparencies used to expose the board are accurately aligned, since errors could result in the pads being drilled away on one side of the board. All holes are 0.8mm except for the 50 way pcb header connector holes which are 1.0mm.

If the board is not plated through, it will be necessary to use pins, or short lengths of tinned copper wire soldered both sides. Where a change of layer occurs, in all, 99 pins are required. Some of these soldered joints are very close together, so great care will be needed to avoid shorts between adjacent conductors. IC1 to IC5 may be soldered

COMPONENTS

RESISTORS

R1	680Ω 0.25Watt

CAPACITORS

C1-C6	100n ceramic (six off)
C7	22µ elect

SEMICONDUCTORS

IC1	74LS32
IC2	~~74LS373~~ 74LS374
IC3	74LS138
IC4	74LS02
IC5	74LS20
D1	1N4148 or similar

MISCELLANEOUS

Printed circuit board, 28pin ic sockets (6 off), 50-way pcb mounting header, 50-way female socket connector (idc), 50-way card edge connector, 75mm length of 50 way ribbon cable, approx 100 pcb pins (see text).

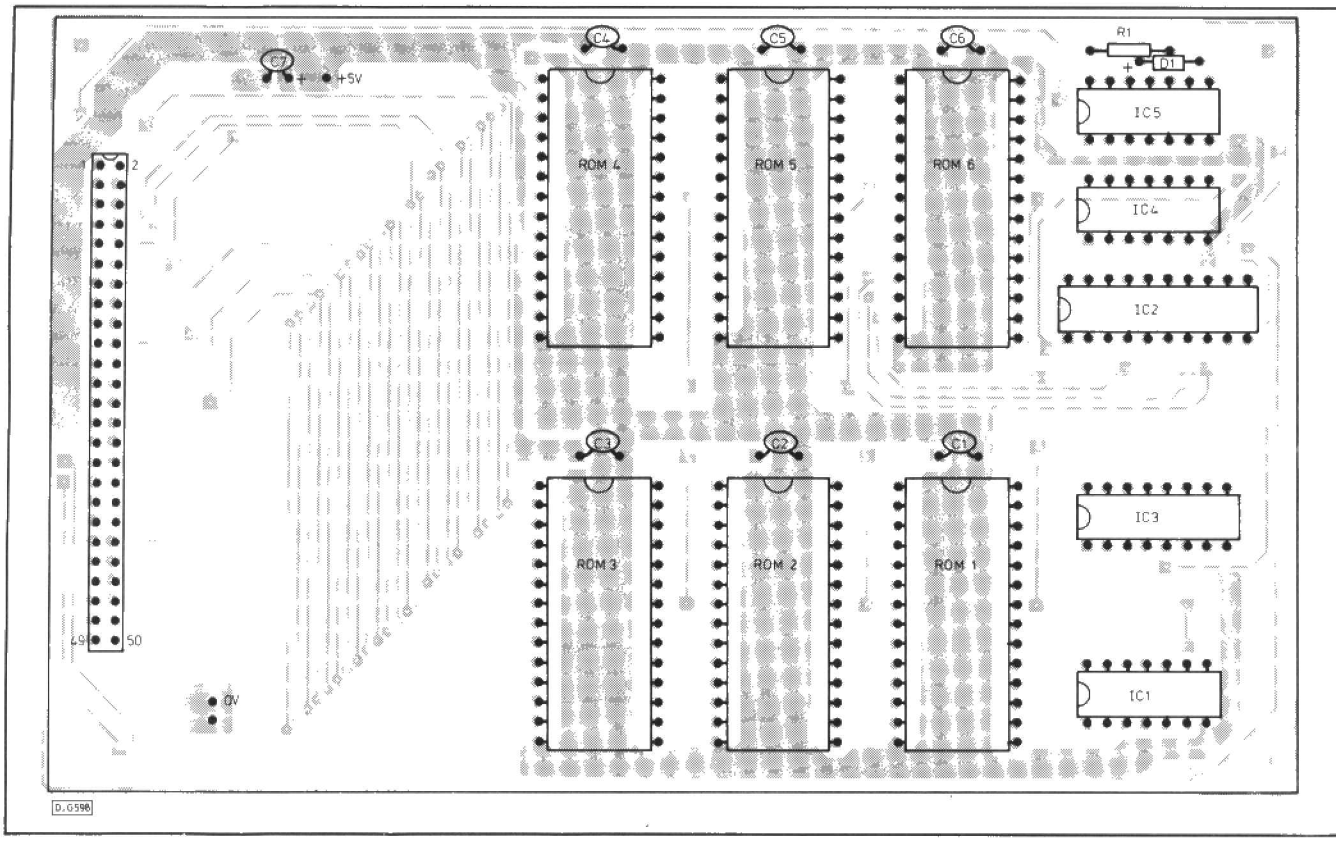


Fig.3. *Component layout details (only top tracking is shown).*

directly into the board, but 28 pin dil sockets should be used for the six roms since these will probably be removed and re-inserted from time to time. The wires of decoupling capacitors C1-C6 should be soldered on both sides of the board, since in some cases they are used to connect the layer together.

The board is fitted with a 50-way pcb header allowing connection to the computer to be quickly and neatly made. A short length (approximately 2-3 inches) of 50-way ribbon cable is required, fitted with a matching female socket connector at one end and a 50-way card edge connector at the other (to fit the Amstrad's expansion connector). This method of connection is not the cheapest way to connect the board to the computer, but it makes further expansion of the system very neat and simple. The card edge connector should ideally be fitted with a locating peg in the position shown in the Amstrad user instructions, to make it impossible to insert the connector into the expansion socket upside down. Users of the DD1 disk interface will unfortunately have to provide a through connection of the bus to allow both units to be used simultaneously.

TESTING

Remove any roms from the board, and connect it to the computer's expansion connector *with the power switched off*. Switch on the computer, and watch for the normal Amstrad start up message.

Program 1

```
10 REM Expansion Board Test
Program
20 DEFINT a,b
30 MODE 1
40 b=0
50 MEMORY &9FFF
60 FOR A=&A000 TO &A010
70 READ D:POKE A,D
80 NEXT
90 DATA, &DD,&4E,0,&CD,&15,
&B9, &DD,&6E,2,&DD,&66,3,
&77, &23,&36,0,&C9
100 PPINT "Expansion ROM Test
Program": PRINT
110 FOR a=1 TO 7
120 CALL &A000,@b,a
130 PRINT a;:IF b=0 THEN
PRINT"....Foreground" ELSE IF
b=1 THEN PRINT"....Background"
ELSE IF b‹ ›80 THEN PRINT"....
Empty"
140 NEXT
```

If no power-up message appears or random patterns appear on the screen, *switch off immediately* and check all wiring and joints carefully. When all appears to be well, type in Program 1 and save it. The program calls jumpblock entry &B915 – KL PROBE ROM for each of the six sockets, and tests the result to decide which type of rom, if any, is present.

RUN the program, and the following message should appear on the screen:–

```
Expansion Board Test Program
1....Empty
2....Empty
3....Empty
4....Empty
5....Empty
6....Empty
```

If a ready programmed rom is available, it can now be inserted (remember to switch off the power whenever roms are fitted or removed). If the power is then applied, the normal power up message should appear, and if Program 1 is re-loaded and run, the rom type should appear against the socket number in which the rom is fitted. You may wish to try the rom in each socket to test the board fully. All that remains is to type in the command(s) required to activate the ROM, and make use of your new found power! **PE**

POINTS ARISING

Egg Timer Jan 88.

The PCB track shown for Fig. 2 should be amended so that: IC4 pins 9 and 13 are connected; IC2 pin 2 goes to IC2 pin 10 and not to Pin 11. Polarity of D1 and D2 should be reversed. In Fig 4 labels to TR9, 10, 16, 15, 14, 13, 12, 11 should read TR 16, 15, 14, 13, 12, 11, 10, respectively.

START MAKING SENSORS

BY TOM IVALL

Like an octopus, electronics is reaching out from its centre to touch and sense conditions in the outside world. In time it is possible that the centre will change altogether into something only to be guessed at present.

British Rail's research and development people recently had a tricky problem in measuring a physical variable. They wanted a force transducer that could be mounted on the pantograph head of a BR electric locomotive and would sense rapid mechanical impacts at forces up to a thousand newtons. Considering that 1000N is something like the weight of a hundred 1-kilogram bags of sugar, it seems like an easy job for a conventional transducer.

The trouble is, in our field we usually tend to think of transducers as devices which convert some physical variable straight into an electrical signal. But in this case an electrical signal had to be ruled out, because its measurement accuracy would be badly affected by electromagnetic interference coming from the power lines and pantograph.

A solution was found by ERA Technology, the independent r&d organization at Leatherhead, Surrey. They designed a force transducer based on optical fibre. It works on the principle of photoelasticity. The applied force deforms the fibre and so modulates the light passing through it. The change in the transmitted light then passes along the optical fibre to a distant electronic photodetector system, well away from the electrical interference source.

I mention this novel technique because it illustrates two things that are happening to the electronics industry through the changing directions of its technology. One is the fairly obvious impact of optical methods generally. If you have a cd player, with its laser beam and photoelectric sensing system, you will be well aware of this. If you talk on the telephone over trunk routes your voice signals are very likely being transmitted as optical binary digit pulses on optical fibre cables.

In science and industry the techniques combining optics and electronics are less obvious but very widespread. Two examples are vision systems for guiding robots, and optical gyroscopes for stabilising satellites and their launching rockets.

Rather more subtle is the nature of the interactions occurring between electronic systems and the outside world. A familiar image here is the human being sitting in front of a personal computer – the man-machine interface. But in the system-world interface of the British Rail apparatus, note what is happening. The conditions in the external environment – the presence of em interference – force the electronics technology away from its normal methods (the use of a conventional transducer) so that something different has to be developed. In fact the electronics is literally being driven back into its information-processing box of equipment – where, perhaps, some older engineers feel it really belongs.

But this is by no means the rule. In other applications the electronics seems to be finding its way out in the opposite direction, nearer and nearer towards the physical variables in the outside world. A good example is what is being called, in American parlance, the 'smart sensor'.

Here we leave optics and consider advances in semiconductor devices. In the smart sensor some of the normally separate information-processing electronics is built into the sensing head itself. Significantly, in this kind of transducer, moving mechanical parts are being integrated with electronic circuits into a single, monolithic silicon chip.

To achieve this, the batch processing methods used in conventional semiconductor device manufacture are being supplemented by 'micromachining', as it's becoming known. What this seems to promise for the future is the small, cheap transducer with its primary sensing element and detection and signal conditioning circuits all provided in one component without the need for an assembly stage. For example, certain semiconductor pressure transducers on the market use a monolithic chip which embodies a piezoresistive bridge strain gauge element integrated with a small active circuit of one transistor and two resistors for temperature compensation.

The motivation behind this approach, as with so many others, is largely economic. Transducers assembled from a variety of parts by conventional methods are considered to be far too expensive in relation to the electronic devices which handle the signal information they provide.

Of course, in addition to the physical variables I've mentioned so far there are others that are either being used at system-world interfaces already, or could well be used in the future. The input energy to transducers, for example, can be mechanical, chemical, magnetic, electrical, radiant, thermal, to name the principal categories. And if we consider actuators – output transducers as distinct from sensing ones – the same categories of energy can be used to act upon the outside world in response to electrical signals.

What I am suggesting in general is that the peripheral technologies of electronics – transducers being one example – are changing the very shape of the industry itself. By the end of this century, in fact, electronics may no longer exist as a sharply defined area of technology and manufacturing. Just as radio engineering spawned electronics, which then proceeded to absorb its parent, the same thing may happen again – several times over.

On this principle we might look at other branches of science and technology which have connections with electronics and speculate if they would be capable of such absorption. Optics, perhaps, computer science, chemistry...? Or we might even consider the complete fragmentation of electronics into a variety of other technologies and interdisciplinary activities, some of which don't yet exist.

Looking at present trends does take us a little way – greater complexity and higher performance in electronic products, more devices on a semiconductor chip, changes in computer architecture and so on.

Several laboratories are now exploring the possible use of biological structures as transducers and energy converters. Could this lead, perhaps, to a probabilistic, rather than rigidly deterministic, principle of information processing and transmission, analogous to that in the animal central nervous system? PE

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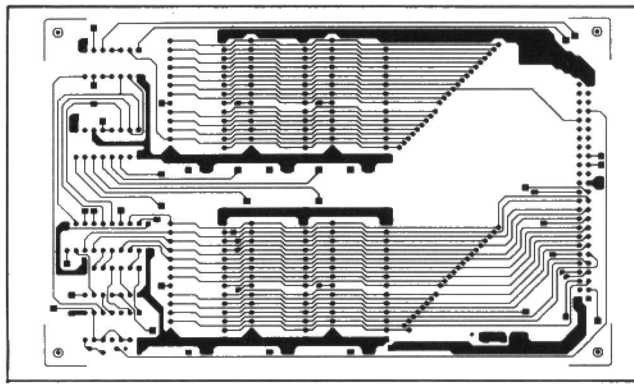

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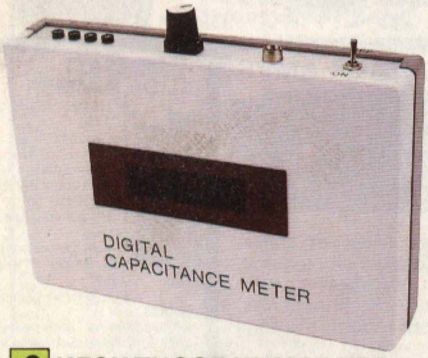

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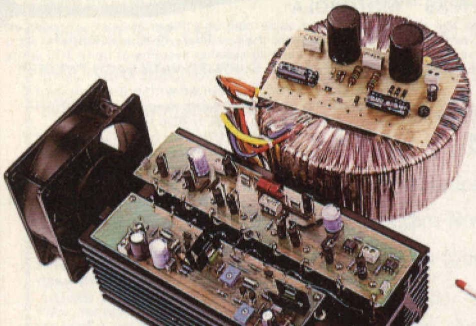

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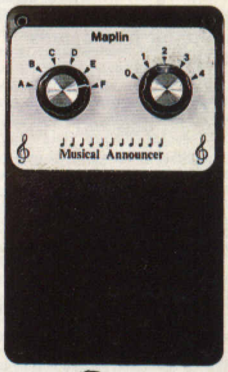

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